SUMMARIES OF PAPERS

JUNE 14-24
LEXINGTON, KENTUCKY, U.S.A.

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE

Summaries of 472 papers presented at the 14th International Grasslands Congress, held at the University of Kentucky, Lexington, Kentucky, June 14-24, 1981.

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XIV INTERNATIONAL GRASSLAND CONGRESS

1981

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J. ALLAN SMITH, Editor
VIRGIL W. HAYS, Chairman,
Publications Committee

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE

GREETINGS

The American Forage and Grassland Council and the College of Agriculture, University of Kentucky are delighted to co-sponsor the XIV International Grassland Congress. We welcome Congress participants and encourage them to savor the amenities of the Bluegrass State.

Grasslands constitute a great national resource in the U.S. and have been especially appreciated in the Commonwealth of Kentucky from before its official founding. Owing to the long history and continuing importance of grassland agriculture in the Commonwealth the University of Kentucky and its College of Agriculture have given strong support to research, teaching, and extension activities related to use and improvement of forages and grasslands.

The history of the American Forage and Grassland Council and its parent organizations dates from 1944. Membership is open to any person, firm, organization, or representative of a public agency with a sincere interest in forages. Currently, members are from the U.S., Canada, and a few other countries. Seventeen state and provincial Affiliate Councils are an integral part of the organization.

We wish success for the Congress and a pleasant and profitable visit for participants and their families.

Charles E. Barnhart

Charles E. Barnhart, Dean
College of Agriculture
University of Kentucky

William C. Templeton, Jr.

William C. Templeton, Jr.,
President
American Forage and
Grassland Council

PREFACE

It has been nearly 30 years since an International Grassland Congress has been held in North America, and we look forward to meeting the many scientists and practitioners from all over the world who will be in attendance at the XIV International Grassland Congress in Lexington, Kentucky.

The importance of the world's grassland resources in meeting the increasing demand for food and fiber is receiving renewed attention. We are confident that the Congress will contribute significantly to further strengthen the forage-livestock production systems of the world and improve the environment in which we live.

This collection of summaries of papers presented at the Congress provides a ready source of information pertinent to the improvement of the world's grassland resources. We are pleased with the excellent quality of the papers and wish to thank all those who have contributed their time, effort and research results and ideas.

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XIV International Grassland Congress

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INTRODUCTION

This publication records the summaries of invited and voluntary papers presented at the XIV International Grassland Congress held on the University of Kentucky campus, June 14-24, 1981. For the most part the summaries have been photo-reproduced from the original copy submitted by the authors. Some have been slightly amended and others have been edited and retyped. Hopefully, the author's original meaning and interpretations were retained.

Summaries of the invited plenary papers are presented on pages 1 to 10. The voluntary papers are organized and numbered according to the 14 broad subject matter sections and the numerous subsections, sessions, in the program. For example, in reading the paper numbers from right to left, paper number 1-4-5 on page 30 is a summary of paper 5 of session 4 of subject matter section 1. The subject matter sections are listed in the table of contents. The summaries are arranged in numerical order by section and session within section so that participants may readily find the summaries associated with each presentation.

Approximately 300 of the 472 papers will be accepted for publication in the proceedings of the Congress. The proceedings will be published by Westview Press, Boulder, Colorado and should be available in early 1982. A copy will be mailed to each full member of the Congress. Additional copies may be purchased directly from Westview Press.

Limited copies of these abstracts are available from the Congress office at a price of $6.50 each.

Virgil W. Hays

J. Allan Smith

CONTENTS

Summaries of Papers Presented at Plenary Sessions	1
Section I -- Plant Introduction, Evaluation and Breeding	11
Section II -- Seed Production	95
Section III -- Soil Fertility	110
Section IV -- The Nitrogen Cycle	143
Section V -- Multiple Use of Grassland	156
Section VI -- Physiological Processes	181
Section VII -- Grassland Ecology	209
Section VIII -- Evaluation Techniques	259
Section IX -- Management of Grazed and Conserved Forages	287
Section X -- Mechanization and Treatment of Forages	337
Section XI -- Utilization of Forages in Animal Production	363
Section XII -- Tropical Grasslands	410
Section XIII -- Transfer of Grassland Research Findings	440
Section XIV -- Socio-Economic Aspects	461
Author Index	473

Forage Quality: Assessing the Plant-Animal Complex

D. J. Minson
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At the Sixth International Grassland Congress held at Pennsylvania State College in 1952, the late Dr. C.P. McMeekan reviewed the many problems associated with the plant/animal complex. Great stress was placed on the need to accurately measure forage intake as a prerequisite to an understanding of the plant/animal complex.

Progress in the development of more accurate methods of estimating the forage intake of grazing animals is reviewed including the introduction of different methods of administering chromic oxide, the oesophageal fistula for obtaining samples of selectively grazed material, the *in vitro* technique for estimating the digestibility of the forage eaten and the use of grazing behaviour and bite size data. Many different methods of measuring forage intake are available but none of these has a high degree of accuracy.

The absence of accurate methods of measuring forage intake has led to use of other approaches to study the plant/animal complex. The existence of a critical bite size below which intake will be depressed is considered. It is shown that the critical bite size will only be achieved when the yields of desired forage exceed about 1000 kg/ha. Grazing animals prefer green leaf and in many cases rejection of the stem and dead material is so great that only green leaf should be considered when determining if sufficient forage is available for the grazing animal to achieve the critical bite size. In mixed pasture animals will tend to prefer certain species and the yield of these species will determine whether maximum voluntary intake of forage will be achieved. The possibilities of using fertilizers to change this preference rating in favour of a plant of higher nutritive value is discussed together with problems associated with the low intake of the stem fraction.

It is concluded that major advances have been made in our knowledge of the plant/animal complex and most of this has been achieved without using accurate methods of measuring the forage intake by animals. This progress was achieved by bringing together the skills of many different disciplines and there is a continuing need to have individual scientists who have trained in both the plant and animal sciences.

Key words: intake, grazing behaviour, chromic oxide, feces, fertilizer, odor, leaves, stem, preference.

Use of Genetic Resources for Improvement of Forage Species

J. R. Harlan
Professor of Plant Genetics, University of Illinois, U.S.A.

The use of genetic resources of forage species poses some special problems because of the number of species involved, the inadequacy of our knowledge about them, the fact that they are often used in combination and should be evaluated in terms of livestock product, and so on. Collections should be as comprehensive as possible at the outset of improvement programs, otherwise there may be much use of inferior material and much waste of time and effort.

Most of the forage species in use come from: (a) Europe (excluding Mediterranean zones), (b) Mediterranean Basin and Near East, (c) African savannas (mostly tropical grasses), and (d) tropical America (mostly tropical legumes). They tend to be members of grazing subclimax or plants with weedy or colonizer habits.

Utilization strategies depend on stage of development of research programs: (a) useful species are introduced unintentionally, (b) a range of materials is assembled, tested and selected entries used, (c) a breeding program is developed using extensive hybridization to identify elite parents, (d) a full scale team is developed with pathologists, entomologists, biochemists, animal scientists, soil scientists and so on. Such teams are unlikely to develop in the Third World without international cooperation.

International cooperation should be encouraged, and the logical coordinator at the present time is the International Board for Plant Genetic Resources.

Key words: germ plasm, collections, centers of origin, plant breeding, biosystematics, international cooperation.

Potential Productivity of Temperate and Tropical Grassland Systems

G. O. Mott
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Grasses of temperate regions of the world belong primarily to the subfamily Festucoideae and tropical regions are populated by tribes of the Panicoideae subfamily. Temperate grasses have a C_3 biochemical pathway of photosynthesis in contrast to tropical grasses which have a C_4 photosynthetic mechanism. Both tropical and temperate legumes are C_3 plants. Compatible mixtures of legumes and grasses have long been successful in many temperate regions but combining C_4 grasses and C_3 legumes as mixtures in the tropics has been only moderately successful.

Maximum net primary productions of temperate and tropical grasslands are in the order of 25 and 80 tons/ha/yr respectively. Thirty tons/ha/yr is considered an exceptionally high yield in the wet-dry tropics and no more than 10 to 15 tons/ha/yr can be expected at 40° N latitude. Breeding of new cultivars has a much longer history in temperate species than in the tropicals. Development of improved evaluation techniques for studying factors which affect sward performance and quality should result in rapid progress in release of new cultivars which are more productive, persistent under grazing, compatible in mixtures and higher in quality.

It is apparent that rates of conversion of net primary production in temperate and tropical grasslands to animal yield are quite different. Even though net primary production in tropical grasslands may be several times that of the most productive temperate grasslands, a much smaller proportion of the production may be recovered by the grazing animal. Animal yields/ha/yr on high producing cultivated temperate and tropical pastures seldom exceed 1000 kg. Failure of tropical pastures to give higher yields of meat and milk commensurate with their greater net primary production can be partially accounted for by much greater losses in the grazing process. Other factors are lower daily intakes of energy above maintenance which results in a much larger proportion of the energy consumed per hectare to be expended for maintenance rather than performance. Higher fiber contents, lower protein levels and mineral deficiencies are only a few of the factors responsible for low conversion efficiency in tropical grasslands.

It is concluded that more nearly maximum yields of animal product for any particular environmental circumstance will be attainable when management schemes are devised to match feed supply with demand, and recover maximum net primary production mutually beneficial to both pasture and animal. Other strategies are to improve the quality of consumed forage by genetic manipulation, development of legume and grass cultivars which will coexist in mixtures, conservation of forages and supplying the mineral requirements of the grazing animals.

Key words: production, animal yield, nutritive value, voluntary intake, grasses, legumes, cultivars.

Contribution of Forages to Worldwide Food Production: Now and in the Future

E. F. Henzell
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Herbivorous livestock provided during the 1970's an estimated minimum 7-17% of the total dietary protein in Asia and Africa compared with about 30% in Latin America and just over 30% in the developed countries. Cattle accounted for approximately 70% of the world's domestic animals (calculated in units weighted for size), buffaloes for 10% and sheep and goats for 11%. About 69% of these animal units were in the developing countries, but productivity was higher in the developed countries. Forages, defined broadly to include all edible plant materials except grains and protein meals, provided more than 90% of the feed energy consumed by herbivorous livestock. Most of the feedgrain was used in developed countries.

Forages can make an important contribution to future world food supplies by providing greater amounts of meats and dairy products at acceptable prices. They can also help to increase supplies of plant foods for people by 1) replacing grains and other potential human foods now fed to herbivores, 2) allowing food crops to be grown on the arable land now used for forage production (through increased yield of forages on non-arable land), 3) improving the fertility of arable land, 4) allowing economies in the use of fuel and nitrogenous fertilizer, and 5) earning foreign exchange to pay for food imports.

Improvement of forage productivity is likely to be limited by the availability of labour and capital and by the decreasing quality of grazing land. Population growth alone will substantially increase the demand for foods of animal origin by the year 2000. It will also be increased by any growth in purchasing power, especially among the people of the developing countries. The failure of domestic herbivore numbers to keep pace with the human population during the 1970's indicates that the world's forage scientists are facing a major challenge.

Key words: protein foods, herbivorous livestock, pastures, fodders, feedgrains, economic development.

Practical Livestock-Forage Systems: Model to Manager

R. W. Brougham
Department of Scientific and Industrial Research, New Zealand

The development of practical livestock/forage systems research during this century is outlined and present day approaches are discussed. Results are also presented for some different regions of the world indicating that livestock production levels obtained from livestock/forage systems research remain appreciably higher than levels being obtained from the best farmers. This type of result has been obtained using a number of different research approaches. The value of these different approaches is commented upon as is the significance of the research to extensionists and managers (farmers).

The need for different levels of research approach and extension in the development of practical livestock/forage systems in "developing" as opposed to "developed" agricultural economies is stressed. The dependence of this on further research at all levels especially in providing more hard factual data for all regions is also stressed.

Key words: livestock-forage systems, research methods, systems research, research needs, research/extension, research/farmer.

Nitrogen Relationships in Grassland Ecosystems

Alec Lazenby
The Grassland Research Institute, Hurley, U.K.

Some recent findings affecting nitrogen (N)-cycling in grassland ecosystems are discussed and mention is made of the increasing importance of modern techniques for such studies.

A brief description of the N in soil organic matter is followed by an account of symbiotic N-fixation by legumes, including some consideration of estimated levels of fixation and factors affecting the process. Data are presented on N-transfer from legumes to soil and on the level of its availability for plant growth, indicated by dry matter (DM) yields on unfertilized all-grass swards.

Studies on nutrient uptake indicate that grass can attain its potential growth rate with very low N-concentrations in solution, provided they are maintained, thus suggesting a possible role for slow release fertilizers; selection for more efficient conversion by grasses of N to DM also appears a possibility. Simple models are presented suggesting likely levels of N-recovery and N-balances in cut and grazed grass swards.

An evaluation is attempted of the relative importance of the pathways of N-loss in grassland. The most significant pathway is volatilization of ammonia causing losses, the levels of which are indicated, both from excreta deposited directly on to the pasture and from slurry. Losses from denitrification and leaching are generally less than from volatilization though they can be significant under conditions which are described.

Legumes and fertilizer are compared as sources of N in grassland ecosystems. Further quantification of processes and pathways of the nutrient in grassland is necessary in order to improve our understanding and enable more efficient use of N in practice. Problems are suggested for research and development in an attempt to achieve these objectives.

Key words: nitrogen, grassland ecosystems, fixation, fertilizer, recovery, transfer, losses, animal utilization.

Multiple Use of Grassland Resources
(Grasslands to Provide Natural Resource Conservation and a Quality Environment for Mankind)

P. J. Edwards
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The grasslands of the world (and communities closely akin to them such as shrub and savanna types) provide not only a very effective mantle for the protection of the soil of the earth, but also the main source of feed for herbivore and cater for many other needs of mankind. Increasing population results in competition between types of grassland use for specific sites. Sound planning is necessary to resolve this conflict in the way most beneficial to mankind.

In order to plan logically it is necessary to make an inventory of the resources, to consider the various uses to which grasslands can be put and to match the resources to the uses with the least disruption of the grassland. The inventory of the resources should identify the main characteristics of the climate, soil, physiography and vegetation at each grassland site. The uses to which natural grasslands can be put are divided on the basis of the extent to which they are disrupted. Those which maintain the natural grassland are grazing land, habitats for wild animals, recreation areas, genetic pool reserves, water source areas and several other direct uses. The group of uses which result in drastic alteration include improved grasslands for grazing and sap extraction, cropping and afforestation, and urban development.

The management of natural grasslands is a vast subject but one which is critical for the maintenance of this steadily deteriorating vegetation. It is very difficult to restore degenerated natural grassland to its original composition and productivity. It is suggested that the most useful strategies available to the manager of natural grassland are fencing, control of stocking rates, fire, stocking density and rotation of grazing, and by long periods of deferment from grazing.

The maintenance of existing grassland which is in good condition should take precedence over reclamation. The reclamation of areas where soil loss is not excessive should be catered for before attention is given to severely degraded areas.

Three groups are identified in the planning of grassland. These are grassland scientists, planners and policy makers. It is the responsibility of grassland scientists to acquire the necessary data and to present it in an acceptable form to the other groups. He must also ensure that his voice is heard when his data have been ignored in the planning process.

Key words: grassland inventory, grassland uses, management, reclamation, planning.

Physiological and Morphological Advances for Forage Improvement

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Forage production basically involves the conversion of environmental inputs such as light energy, CO_2, water and soil nutrients to provide digestible energy and other nutrients for ruminant livestock. In attempting to improve this conversion, the plant breeder needs to consider the seasonal inputs or constraints in his particular environment, the efficiency of the crop in responding to these factors, those physiological or morphological features of the plant which contribute to this efficiency, and how far they can be modified by selection and breeding.

The primary climatic variable determining crop photosynthesis and production growth is the seasonal input of light energy, but in most grassland environments growth or even survival of the crop can be limited by temperature or water stress, whilst shortage of soil nutrients, particularly nitrogen, is usually an important limitation.

The net photosynthetic efficiency of any crop will be influenced by the photosynthetic rate of the individual leaves, by their arrangement in relation to light interception and by the extent of respiratory losses. In forage crops, the harvestable yield including regrowth under different defoliation regimes and persistency, is also influenced by the partition of assimilates between shoot and root development and between flowering and continued vegetative growth. Response to seasonal limitations of temperature or water stress often involves two conflicting requirements, the ability to continue active growth under moderate stress, and/or survival of more extreme conditions, often involving a degree of dormancy. Furthermore the physical and chemical constitution of the harvested material is important in determining digestibility and intake, and hence animal production.

Considerable genetic variation is available within forage species for many physiological or morphological features, which influence the response of the crop to the above inputs or constraints. In attempting to make use of this variation, the plant breeder has to consider which features are most important in determining seasonal production in the field, and how far rapid and reliable selection criteria can be developed which compare favourably with the standard methods of field assessment of breeding material. Such rapid screening techniques can be of particular value where production is limited by one major but unpredictable climatic factor such as low temperature or water shortage, or where rapid laboratory techniques can be developed for the assessment of nutritional components. At the present time the potential benefits of screening for the various components of crop photosynthesis including maximum photosynthetic rate of the individual leaf, photorespiration, and leaf arrangement are rather more speculative, though selection for reduced respiratory losses has shown promise.

Key words: assimilative partitioning, leaf arrangement, nutritive quality, photosynthesis, plant breeding, respiration, water stress, temperature.

Resource Allocation for Animal Grassland Systems

Gerald W. Thomas
President
New Mexico State University

The production of animal products from grasslands is dependent upon an adequate resource base -- particularly the availability of land, water and energy. In addition, range and pasture production systems must be designed to adjust to climatic variations and to minimize adverse environmental impacts.

There are several new developments which will have a significant impact on the future allocation of resources for animal agriculture:

(1) Increased competition for land and water which is leading to transfers from agriculture to non-agricultural uses.
(2) Increasing costs and availability of "cultural energy" (particularly fossil fuels).
(3) More pressure to divert grains and feed concentrates from animals to direct human food, thus increasing the dependence on roughages.
(4) Regional and world-wide changes in types and classes of livestock and systems of production.
(5) A greater environmental awareness and more recognition of the role of wildlife and other multiple-use aspects of grasslands.
(6) Impacts of fast-food chains, new grading standards, more concern for human health and appropriate diets with less animal fat.
(7) The emerging role of the Less Developed Countries as they attempt to offset substantial population increases by producing more food, moving toward "appropriate technology," and utilizing new innovations for animal disease control and production.

Key words: natural resources, environment, water, land, energy, climate, vegetation, animal agriculture.

Grassland Development in Japan and Other Asian Countries

I.Nikki
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It was not till World War II that attention was first directed to grassland in Japan. Forage crops began to be grown on dairy farmers' fields for feeding cattle. Their acreage has increased, being equivalent to 15% of the total area of the fields. Now forage is the second major crop, next to rice. On the basis of the New Grassland Law which was approved in 1950, the "grassland improvement" was started and developed into the establishment of sown pastures. Japan, situated in the most northern part of the Asian Monsoon Area, is warm as a rule and has much rainfall. Miscanthus sinensis Steud. and Zoysia japonica Steud. are the representative, dominant species of natural grassland. Most of the grassland soil, supposedly improved, is of volcanic ash. Red clover (Trifolium pratense L.), orchardgrass (Dactylis glomerata L.), etc. have been settling in the sown pastures, while such temperate weather species as bahiagrass (Paspalum notatum Flugge) is found more in warmer regions. Because of the Japanese climate, silage is preferred to hay. Making silage of high quality and high calory content is most important to grasslandmen. Research organizations have been established over the past 25 years. The National Grassland Research Institute is one of these. As to higher education, the Department of Grassland Science was established at Obihiro University and Miyazaki University. In Japan, there still remain large areas of mountain land that can be utilized by grazing by cattle after some improvement. According to government survey, 1.29 million ha of land is regarded as suitable for grassland. Japan imports huge amounts of feed grain, constituting a grave problem from the world food viewpoint. This is also the most essential problem concerning Japanese national security. Although the climate of Japan, as a rule, is favourable for producing forage, there still remain various problems to be solved. Most of them could not be resolved without systematic research. Turning to Asia, out of the many countries China, Outer Mongolia, The Philippines and Thailand were selected as examples in the present paper. It is, however, a recent tendency that in most Asian countries the demand for milk and meat has been increasing remarkably. Thus grassland farming is attracting great interest in those countries. Judging from bygone experiences in these countries, grassland farming must be promising. The grassland farming in Asia probably has unique characteristics due to the peculiar environment of Asia. There are many difficult problems to be solved. To those of us, on the way to developing grassland farming, nothing could be of greater help than the international exchange of knowledge and information.

Key words: grassland development, Asia, Japan, Mongolia, Philippines, Thailand.

1-1-1 Seedling Traits as Possible Selection Tools for Improving Seedling Emergence of *Astragalus cicer* L.

C. E. Townsend
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Cicer milkvetch (*Astragalus cicer* L.), a nonbloating legume, has many attributes of a desirable forage species. Relatively poor seedling vigor, however, has limited its use. Our objectives were to determine the variability among selected progenies of cicer milkvetch for seedling vigor traits in the laboratory and for seedling emergence in the field, and whether these seedling traits can be used to predict seedling emergence in the field.

A total of 112 polycross progenies from three selected populations were evaluated for seedling vigor traits at a 15/25 C temperature in the laboratory and for seedling emergence at two field locations. In all instances the experimental design was a randomized complete block with four replications.

Differences among populations were relatively small for all seedling traits. Mean radicle length, hypocotyl length, hypocotyl diameter, total seedling length, and seedling weight ranged from 36 to 37 mm, 25 to 26 mm, 1.19 to 1.27 mm, 61 to 64 mm, and 3.29 to 3.88 mg, respectively. Within populations the progenies differed significantly (5% level) for all seedling traits.

Progenies within populations differed significantly for seedling emergence at both locations. Seedling emergence at one location was about twice that at the other location.

Of the 30 possible correlation coefficients between the five seedling vigor traits and seedling emergence at the two locations for the three populations, only four were significant and they were of low predictive value. Therefore, seedling traits as developed in a 15/25 C laboratory environment were not suitable for predicting seedling emergence of cicer milkvetch under field conditions.

Key words: cicer milkvetch, *Astragalus cicer* L., seedling emergence, seedling traits, seedling vigor.

1-1-2 Germination and Seedling Establishment of *Bromus unifoloides* Kunth, *Lolium multiflorum* Lam. and *Festuca arundinacea* Schreb.

M. J. Hill and C. J. Pearson
University of Sydney, Australia

Rapid seedling establishment is an important factor in increasing winter production of irrigated dairy and beef pastures in temperate Australia. This is particularly so when temperate species are sod-sown into sub-tropical summer pastures in late summer or early autumn. Seedlings are subjected to active competition from the moment of emergence. Our aim was to compare commonly used annual ryegrasses, having proven seedling vigour, with perennial species to test their suitability for sod-sowing practices.

Germination and seedling establishment of prairie grass (*Bromus unioloides* Kunth, 2 lines), Italian ryegrass (*Lolium multiflorum* Lam., 2 lines) and tall fescue (*Festuca arundinacea* Schreb., 4 lines) from New Zealand, Australia and the U.S.A. were examined in temperature controlled glasshouses at 15/10, 18/13, 21/16, 24/19 and 30/25°C (day/night). Radical emergence and "field emergence" - when the shoot was greater than one centimetre long - were recorded every two days on seeds in petri dishes. Seedling dry weight production (top only) was measured after twenty days from sowing on plants growing in fertilized sand.

Curves of the form $P = A(1-\exp(-k(t-t_0)))$, where P is the percentage of seed germinated at time t, t_0 is time to first germination, k is a measure of the spread in the population of the time to germination and A is the germinability, were fitted to the germination data.

Spread of the time to germination was greatest at 15/10 and 30/25°C and least at 21/16 and 24/19°C for all lines. Germinability tended to decline at 24/19 and 30/25°C. Ucivex and Tama Italian ryegrasses were consistently the fastest germinators, while Kangaroo Valley prairie grass (uncertified) was appreciably slower than all other lines, particularly at 15/10 and 18/13°C. Matua prairie grass and all tall fescue lines were very similar in time to first germination under all temperature regimes.

Maximum seedling dry weight for all species and lines occurred at 24/19°C. Tama ryegrass was the most productive line at all temperatures. The prairie grass lines and Ucivex ryegrass were comparable in yield from 15/10 to 24/19°C. The tall fescues - AF5 and AF6 (Alabama), Kenhy (Kentucky) and Demeter (Australia) - had slow seedling growth and were not significantly different under any temperature regime. Growth rates, calculated from first emergence, followed the same pattern as dry weight of tops, with however the prairie grasses clearly second to Tama ryegrass at 15/10, 18/13 and 21/16°C

Tall fescue with a small seed and slow seedling growth is unsuitable for rapid production from sod-sowing. Matua prairie grass with a large relatively quick growing seedling could produce feed quickly after sod-sowing despite a slower germination rate than Italian ryegrass. The difference between the seedling vigour of the ryegrasses may be attributed to Tama being tetraploid.

Key words: prairie grass, *Bromus unioloides* Kunth, Italian ryegrass, *Lolium multiflorum* Lam., tall fescue, *Festuca arundinacea* Schreb., germination, establishment, temperature.

1-1-3 Seed Size Distribution, Germination and Emergence Characteristics of Five Diverse Old World Bluestem Strains

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The Old World bluestems (OWB) are a complex of highly diverse grasses with the genetic potential to substantially increase beef production throughout the Southern Plains. However, OWB mature seed unevenly and when harvested, the chaffy seed units contain caryopses which range from being immature and small to being well-filled and large. Germination rate and seedling emergence influence seedling establishment in semi-arid climates. The objectives of this research were to determine the distribution of caryopsis size (seed classes) within five strains of Bothriochloa and to measure the effect of seed classes on germination rate and seedling emergence.

Caryopses of each strain were removed from their subtending appendages and separated into five seed classes with wire screens (26, 30, 33, 38 and 47 sieve openings per cm square) and with the South Dakota seed blower (air valve settings of 14, 20, 25, 30 and 40°). Germination studies utilized a randomized complete-block experimental design. Replications consisted of five OWB strains and five seed size classes on moistened substrates in an alternating (16 hr. dark, 20 C, and 8 hr. light, 30 C) environment. Greenhouse seedling emergence studies included five OWB strains, two seed size classes, three soil series and three (5, 10 and 15 mm) planting depths. Seed size classes were large (caryopses which passed through a 20 and retained on a 33 sieve openings per cm square) and small (caryopses which passed through a 38 and retained on a 47 sieve openings per cm square). Treatments were arranged factorially in a randomized complete-block experimental design with eight replications.

Seed classes displayed a unimodal size distribution in all five OWB strains with large differences in distribution patterns among strains. Average caryopsis weight in the small seed classes ranged from 0.10 to 0.25 mg per seed compared to 0.36 to 0.54 mg per seed in the large seed classes. Three to 32% of the pure seed content of the strains studied were in the small seed classes. Germination of caryopses in the small seed classes was low (0 to 38%) in comparison to large seed classes (48 to 87%). Seedlings from the large seed class of all five strains emerged at a significantly faster rate than seedlings from the small seed class regardless of planting depth or soil series. Three of the OWB strains had significantly higher total seedling emergence from the large seed class; whereas, seed size did not appreciably affect total seedling emergence from a particular soil in the other two OWB strains.

Seed class distribution was highly variable among the strains. The distribution pattern of seed class, by strain, influenced the rate of germination and seedling emergence. The distribution of seed classes, germination, and seedling emergence characteristics of a particular OWB strain should be considered in estimating the planting quality of these grasses.

Key words: Old World bluestems, Bothriochloa spp., caryopsis, germination, emergence.

1-1-4 Selection for Bluegreen Aphid Resistance in Subterranean Clover

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Bluegreen aphid (B.G.A.) (Acrythosiphon kondoi Shinji) has recently arrived in Western Australia and poses a serious threat to some 7 million hectares of legume based pastures, 93 per cent of which is sown to subterranean clover (Trifolium subterraneum).

Two experiments were conducted over the summer of 1980 to investigate the resistance of commercial cultivars and breeding lines to B.G.A. In the first experiment, 18 commercial subterranean clovers, three commercial medics (Medicago spp.) and one serradella (Ornithopus compressus) were tested as seven week old plants. The second experiment tested a total of 67 selections, breeding lines and commercial cultivars as seedlings.

Plants were grown in aphid proof cages in controlled environment conditions with 18°C/10°C day/night temperatures. Aphids were applied at the commencement of each experiment and plant damage was monitored at weekly intervals. After four weeks almost 80 per cent of the varieties tested showed damage symptoms ranging from some dead leaves to death of all plants. Symptoms did not develop at the same rate on all varieties. One commercial cultivar and one overseas introduction showed a high level of tolerance to B.G.A.

The relevance of these screening experiments to B.G.A. effects in the field is discussed.

Selection for resistance among the 6,000 genotypes comprising the National Subterranean Clover Collection requires rapid and easily repeatable assessment criteria. The techniques used in these experiments are based on both plant damage and survival and, when used for seedling screening, are well suited to handling large numbers of test varieties.

Key words: bluegreen aphid, Acyrthosiphon kondoi Shinji, resistance, subterranean clover, Trifolium subterraneum.

1-1-5 A Study of the Breeding Potential of a Population of Alfalfa (*Medicago sativa* L.)

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Improved cultivars are the goal of all forage breeding programmes. In alfalfa (*Medicago sativa* L.), large improvements have been made in pest resistance and stability of performance but very little in yield potential. This lack of improvement in yield potential may be due to yield selection under non-competitive conditions. The objective of this study was to evaluate the breeding potential of an alfalfa population when selection was based on performance under competition.

A heterozygous alfalfa population, consisting of F_1 families from crosses between synthetics BW1 and BW9, was used in the study. The F_1 families and polycross progenies of random plants from within each F_1 family were evaluated in a simulated sward under growth room conditions. Dry matter yield was measured over three harvests. The additive and digenic variances and the narrow-sense heritability for dry matter yield of the F_1 population were estimated from the analyses of variance. A number of six clone synthetics were developed from the F_1 population to determine the response to selection.

The estimates of additive variance were significant for dry matter yield at the second harvest and for the total yield. None of the digenic variance estimates were significant. This indicated that the genetic variance in this population was mainly additive, with a narrow-sense heritability for total dry matter yield of 15%.

The genetic coefficient of variation was greatest within the original population of F_1 families. Significant, positive correlations between the F_1 population and polycross progeny yields and the significant additive variance present indicated a potential to improve the F_1 population through phenotypic mass selection.

Comparisons between the experimental synthetics and an unselected bulk of all F_1 families indicated that no response to selection was obtained. Although the mean yield of four synthetics, at the Syn-3 generation, was 7% above that of the bulk, this difference was not significant. Further cycles of selection or a change in the experimental design may be required to detect differences.

Based upon these results, selection gains for yield could be made in this population of alfalfa. Further cycles of mass selection, conducted under sward conditions, is warranted.

Key words: alfalfa, *Medicago sativa* L., synthetics, yield, selection, variances.

1-2-1 Selection of New Subterranean Clover Cultivars for South West Spain

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This paper describes the present situation of subterranean clover based pastures in Spain, the research that has been done to date, and the Spanish Programme for selecting and producing the needed adapted varieties of subterranean clover.

More than half a million hectares have been sown to subterranean clover in Spain but the potential is considerably greater. Several million hectares are devoted to grazing in South West Spain with an average stocking rate of about 1.5 sheep per hectare. Meanwhile, farms which have a part of their land in subterranean clover have stocking rates up to 4.5. Nevertheless sowings using commercial Australian cultivars have failed to persist in many cases. Studies have been conducted to investigate the reasons for this. The pattern of softening of hard seeds under summer temperatures in the open, the differences in maturity grade under Spanish versus Australian environments, the maturity of locally adapted types and the potential of the almost forgotten species of T. brachycalycinum have been studied in Badajoz, Spain.

A germplasm bank has been made available for a selection programme, with nearly 2,000 introductions having a wide genotype representation. A Selection Programme for Subterranean Clover was started in 1977 using our germplasm bank as a source of material to screen out pure lines. Specific criteria have been selected for persistency and quality.

Hundreds of lines are sown each year in the field at Olivenza, Spain, in a proper soil with irrigation facilities. Spaced plants of each line are checked one by one to ensure purity and separating of sublines when necessary. Data of each line are recorded during the whole life cycle, specially related to its morphologic and agronomic characteristics. First generation selections are sown in small plots to increase seed and some agronomic characters continue to be recorded. Purity is again carefully checked in these plots.

A limited number of selected lines will be tested in pure and mixed swards under grazing in various places for final testing and precommercial varieties will be selected for commercial testing.

Key words: subterranean clover, stocking rate, adaptability, selection, morphologic characteristics, agronomic characteristics.

1-2-2 Breeding for Disease Resistance in Red Clover

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Diseases incited by fungi and viruses cause substantial annual losses in the production and quality of red clover (*Trifolium pratense* L.) forage. The most feasible means of controlling red clover diseases is to incorporate genes for disease resistance into agronomically acceptable cultivars or to develop new germplasm with disease resistance. Phenotypic recurrent selection was applied to red clover populations to develop germplasm resistant to northern anthracnose (causal agent-*Kabatiella caulivora* (Kirch.) Karak.), powdery mildew (causal agent-*Erysiphe polygoni* DC ex St. Amans), target spot (causal agent-*Stemphylium sarcinIforme* (Cav.) Wiltshire), leaf rust (causal agent-*Uromyces trifolii* (Hedrow. f. ex DC) Lev var. *fallens* Arth.) and clover rot caused by *Fusarium* spp. The specific steps in the procedure are outlined, and the methods of preparing and applying the respective inoculum are presented. After five cycles of selection for resistance to northern anthracnose and leaf rust, 100 and 85% of the plants were resistant to the respective diseases. The population was improved for resistance to target spot after two cycles and to powdery mildew after one cycle. For those diseases for which resistance is controlled by dominant genetic factors, progeny testing within each cycle would result in more rapid progress per cycle. In addition, parental selects could be evaluated for agronomic performance while progeny testing is being conducted.

Key words: forage breeding, *Trifolium pratense* L., Phenotypic recurrent selection.

1-2-3 Genetic Resistance to *Kabatiella caulivora* in *Trifolium subterraneum*

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Clover scorch caused by the fungus *Kabatiella caulivora* is a serious problem in southern Australia on subterranean clover (*Trifolium subterraneum*). The disease is particularly a problem in higher rainfall areas (>500 mm per annum) and there is an urgent need for resistant cultivars. The aim of this research program was to examine variability in resistance to clover scorch in subterranean clover, to investigate its inheritance and to determine strategies for breeding resistant cultivars.

The pattern of disease development was studied in detail in the field and three disease parameters, Total Disease Development (TDD), Rate and Delay were calculated. Several genotypes exhibited levels of resistance adequate to ensure minimal losses in pasture production. Considerable variation in the pattern of disease development in different genotypes was observed. TDD was highly correlated with a single measure of disease resistance taken in the middle of the epidemic.

Some variation in pathogenicity of the fungus was observed, but no interaction between isolates of the fungus and host genotypes was detected.

A glasshouse tehhnique for screening seedlings for resistance to clover scorch was developed which appeared to have some potential in predicting field resistance. The technique was not sufficiently precise, however, to allow selection for resistance to be carried out solely in the glasshouse, but it may be useful as an initial screening prior to field testing.

Comparing responses to infection over a range of environments showed that the relative levels of resistance of most genotypes were fairly stable. An analytical technique, based on analysis of variance followed by a ranking process, was developed which permits a comparison of rankings between environments and utilizes quantitative variability to determine significant rank order. The results show that potential new cultivars need to be evaluated over a range of environments.

Diallel analysis of F_2 swards indicated that variation in disease resistance is heritable and that genes for resistance are dominant. A study of F_2 and backcross populations, measured as single plants in the field, indicated that there is a single major gene for resistance which exhibits dominance. Differences in resistance between moderately resistant and susceptible lines appeared to be determined by at least four genes of minor effect. It was concluded that effective resistance could best be combined with superior agronomic characteristics by backcrossing.

Key words: clover scorch, *Kabatiella caulivora*, subterranean clover, *Trifolium subterraneum*, resistance.

1-2-4

Subterranean Clover Improvement: An Australian Programme

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At the eleventh International Grasslands Congress we reported on a subterranean clover improvement programme being developed jointly by the University of Western Australia, the Western Australian Department of Agriculture and the CSIRO, Division of Plant Industry, Canberra. Since 1970, the programme has grown to become the National Subterranean Clover Breeding and Improvement Programme and collaboration now also extends to Departments of Agriculture in the states of New South Wales, South Australia and Victoria. The programme is supported by the wheat, wool and meat producers with contributions from federal and state government sources.

Since 1970 the objectives of the programme have become sharper as a result of agronomic and physiological studiess and farmer experience. Factors determining the adaptation of strains can now be better defined.

In addition to the major selection criteria of environmental adaptation and low formononetin, further criteria have been incorporated including tolerance to *Kabatiella caulivora*, root rots and aphids.

Research to support the breeding programme is being undertaken on a wide range of topics.

A gene bank of over 4000 lines has been developed. Observations are maintained in accordance with the practices of the International Board of Plant Genetic Resources.

Since 1975, three crossbreds (Esperance, Nungarin and Trikkala) and one selection (Larisa) have been released as commercial cultivars and several lines are at an advanced stage of testing.

Key Words: subterranean clover, *Trifolium subterraneum*, ssp. *subterraneum*, *brachycalicinum*, *yanninicum*, breeding, genetic resource, EXIR, formenonetin, clover scorch, *Kabatiella caulivora*, aphids, root rot.

1-2-5 Evaluation of Aphid-Resistant Lucernes from the U.S.A. in the Queensland Sub-Tropics

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The occurrence of the spotted alfalfa (Therioaphis trifolii (Monell) F. maculata) and blue-green (Acyrthosiphon kondoi Shinji) aphids in Australia in 1977 led to the importation of aphid resistant lucernes (Medicago sativa L.) from the U.S.A. Our objectives were to evaluate the relative productivity, winter dormancy, persistence and disease resistance of 23 American and 5 Australian genotypes with and without aphicidal treatment. We summarise results obtained during the seeding year from two irrigated (Biloela, lat. 24°24'S and Gatton, 27°33') and two rainfed sites (Biloela and Toowoomba, 27°33') representative of lucerne growing areas in Queensland.

Planting was in winter 1976 and all treatments were protected against aphids in the seedling phase. During the first summer, reactions to the stand debilitating pathogens Phytophthora megasperma var sojae and Colletotrichum trifolii, causing root rot and anthracnose/crown rot respectively, were assessed. Relative dormancy was determined from cumulative yield of three consecutive winter harvests.

Despite high aphid numbers during establishment, only minor infestations occurred subsequently and genotypes either treated with aphicide or untreated performed similarly. First year dry matter production at Biloela with irrigation ranged among genotypes from 19 - 26 t ha^{-1} (10 harvests) and was correlated (r = +0.92) with winter dormancy. Australian and American genotypes belonging to equivalent dormancy classes produced similar yields. At Gatton the yield range was 6 - 16 t ha^{-1} (9 harvests), with yield partially correlated with dormancy (r = +0.71) and relative susceptibility to Phytophthora (r = -0.70). At this site the Australian cultivars performed poorly, due to their high susceptibility to Phytophthora. Annual yields at rainfed sites varied between 5 - 5 t ha^{-1} (6 harvests) at Biloela, where there was no obvious relationship between yield and genotypic characteristics, and non-significantly between 11.5 - 14.5 t ha^{-1} (6 harvests) at Toowoomba. All the semi- and non-dormant imported genotypes had inferior resistance to Colletotrichum compared with Hunter River.

Our early results confirm that Phytophthora-resistant genotypes are advantageous for lucerne production in the sub-tropics. The susceptibility of American genotypes to Colletotrichum also suggests that improved long-term persistence and production of lucerne in our environment remains dependent on the development of multiple disease and pest resistant genotypes.

Key words: lucerne, Medicago sativa L., production, dormancy, Phytophthora, Colletotrichum, aphids.

1-3-1 Second Generation Progeny Tests for Forage Breeding

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Second generation progeny tests were defined as the evaluation of polycross progeny of plants from a set of first generation families. Selection would be done in two steps; identification of first generation families with superior average second generation family performance, followed by selection of superior second generation parents within the superior first generation families. Remnant seeds of superior first generation families could be used to initiate improved populations and cultivars. Second generation progeny testing was studied as part of a continuing search for selection methods that have the following properties: (a) are at least as effective as polycross progeny test selection for all levels of heritability; (b) do not require production of large quantities of seed by hand pollination; and (c) permit storing much of the germplasm as seed instead of clones.

Theoretical changes in gene frequency with second generation progeny tests were computed for diploid and autotetraploid populations in which the first generation families were polycross progeny (PxPx), full-sibs (FSPx), and selfed families (SlPx). The methods used were an extension of those that appear in the quantitative genetic literature.

Theoretical response relative to that of the single generation methods commonly used in forage breeding depended on the number of parents used per first generation family. Theoretical response with PxPx and FSPx selection was always greater than that with polycross progeny test or full-sib family selection, respectively, when the number of parents per first generation family was greater than six. Differences in relative theoretical responses for PxPx and FSPx selection were small. The required minimum number of parents per first generation family could not be computed for SlPx selection.

Key words: progeny test, breeding methods, heritability, forage breeding.

1-3-2 The Problems and Future of Hybrid Alfalfa Breeding by Use of Male-Sterility in Japan

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Hybridization by using male-sterile plants is one of the ways to utilize heterosis directly without emasculation problems. The purposes of this paper are to discuss the problems and to visualize a future of hybrid alfalfa (Medicago sativa L.) breeding by use of male-sterile plants in Japan.

Based on the apparently different segregations of the F_1's of male-sterile plants with common paternal plants, three types of male sterility were identified. Among them, cytoplasmic male sterility is most promising for hybrid alfalfa production. Expression of male sterility is sensitive to environmental conditions such as growth temperature. Identification of male sterility, therefore, should be carried out repeatedly under different conditions.

Apparent heterosis in seed size, early growth and forage yield were found in F_1 hybrids. Heterosis effect on seed size seems to be very important to subsequent early growth and forage yield. Sufficient heterosis among F_1 hybrids of male-sterile plants crossed with normal plants will compensate for the higher cost of seed production.

General combining ability (GCA) in many characters was more important than specific combining ability (SCA). Selection for SCA in heterosis breeding in alfalfa, therefore, should be based on the consideration of additive gene action. From the results, it is evident that selection for GCA would be carried out first and subsequently the selection for SCA should be carried out in the restricted populations.

Bee visitation on male-sterile plants was not inferior to that on normal plants. However, seed yield of male-sterile plants was generally inferior to that of normal plants. Efficiency of bee visitation would seem to be of greater significance than frequency of bee visitation. Great variability of seed fertility among male-sterile plants suggests a need for effective selection for this character.

Cost of seed production is a serious problem in the utilization of hybrid alfalfa in Japan, which has relied upon over-seas production for multiplication of hybrid seed. Hybrid seed production from parental clones propagated vegetatively is too expensive and inapplicable. Inbred lines of male-sterile or normal parents should therefore be utilized for production of seed of alfalfa hybrids.

Key words: alfalfa, Medicago sativa L., hybrid seed production, male sterility.

1-3-3 Root Diameter, Nematodes, and Soil Compaction Affect Forage Yield of Two Tall Fescue Genotypes

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The effect of soil compaction and nematode infestation on both a large- and small-rooted tall fescue (Festuca arundinacea Schreb.) was evaluated. A factorial 2 x 2 x 2 randomized-block experiment was conducted in a soil with a tillage pan and a nematode infestation. The large- and small-rooted tall fescue genotypes were planted in two soil treatments in four combinations: conventional tillage (plow [20 cm depth]-disk) without fumigation; conventional tillage with methyl bromide fumigation; deep tillage (subsoil [38 cm depth]-disk) without fumigation; and deep tillage with methyl bromide fumigation. The genotypes exhibited no differences for water loss (leaf diffusive resistance) or soil-water extraction ability. On a tillage pan, the large-rooted genotype had superior root penetration, forage yield, persistence, and sward cover. Nematodes preferred the large-rooted to the small-rooted genotype. These data indicate that forage yields of tall fescue can be increased by breeding for specific root system characteristics.

Key words: tall fescue, Festuca arundinacea Schreb., root size, forage yield, nematodes, tillage pan.

1-3-4 Pooling the Genetic Resources of the Crested Wheatgrass Species-Complex

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The crested wheatgrasses--Agropyron cristatum (L.) Gaertn., A. desertosum (Fisch. ex Link), and related taxa--comprise a series of diploid (2n = 2x = 14), tetraploid (2n = 4x = 28), and hexaploid (2n = 6x = 42) forms. Dewey (1974) concluded that the same basic genome, modified mainly by structural rearrangements, occurs in the three ploidy levels. He has proposed that breeders should expand the genetic base of their breeding populations by treating all species in the complex as a single gene pool.

Gene flow to the 2x level from tetraploid A. desertorum (N4x) has been restricted by the failure of N4x-2x triploids to produce functional reduced gametes. Dewey (1971) found that triploids from crosses between colchicine-induced tetraploids (C4x) and 2x A. cristatum produced a higher proportion of functional reduced gametes than their N4x-2x counterparts. Dewey (1977) successfully used these triploids in a backcrossing scheme to transfer a recessive marker gene from the 4x to 2x level. The procedure lends itself to introgression of other agronomic traits to the highly uniform 2x level.

Several approaches apparently can be used to convey germplasm from other ploidy levels to the 4x level. Dewey (1971) concluded that stable 4x populations could be derived from (N4x-2x)-N4x backcross progenies. The most promising interploidy breeding populations have stemmed from C4x-N4x crosses. Dewey and Pendse (1968) found that many C4x-N4x hybrids were substantially more vigorous than their parental clones. Also, the C4x-N4x hybrids were relatively fertile and preliminary results indicate that selection for improved fertility would be effective. Dewey (1969) reported that stable 4x populations could be obtained from 6x-C4x and 6x-N4x pentaploids through selection and hybridization with 4x derivatives. Dewey (1973) and Asay and Dewey (1979) found that 6x-2x tetraploids could successfully be used in crosses with N4x tetraploids to combine germplasm from three ploidy levels at the 4x level.

Fully fertile 6x progenies have been obtained in first generation 6x-4x backcross progenies (Dewey 1969, 1974). Results from Dewey's (1974) studies also indicate that 5x-5x crosses will yield fertile 6x progenies. However, the 6x material is agronomically inferior and probably does not warrant a major breeding effort.

Key words: Agropyron cristatum (L.), Agropyron desertorum (Fisch ex Link), grass breeding, introgression, polyploidy, autopolyploidy, sterility, interspecific hybridization, cytogenetics.

1-3-5 Breeding for Higher Magnesium Content in Orchardgrass (*Dactylis glomerata* L.)

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Grass tetany, a metabolic disorder of lactating ruminants caused by low blood serum Mg levels, occurs most often during the winter and spring months in the southeastern United States. During these months, pasture soils are generally wet or flooded and air and soil temperatures are low, so evapotranspiration rates are low, resulting in low soil oxygen concentration (less than 1% O_2). Flooded soil conditions generally affect the relative amounts of Mg, Ca, and K present in the soil solution, and also reduce cation uptake by cool-season perennial forage grasses.

Orchardgrass, an important cool-season perennial forage grass, often contains concentrations of cations which are suboptimal for animal requirements. An experiment was conducted to (a) determine Mg, Ca, and K uptake by orchardgrass cultivars when grown in nonflooded and flooded soil, and (b) determine if a selection program would be effective in isolating genotypes capable of high Mg uptake under these conditions. Five clonal propagules of 80 genotypes were grown in flooded and nonflooded soil in a glasshouse. After 6 weeks, the top growth was harvested and the forage Mg, Ca, and K contents were determined.

Flooded soil reduced Mg and K content and increased Ca content in the orchardgrass forage. Dry weights were lower and root numbers were higher on plants grown in flooded soil than in nonflooded soil. Significant differences were obtained among the cultivar means for Mg and Ca in nonflooded soil, and Mg, Ca, and K in flooded soil. Root number was correlated with Mg and Ca in flooded soil. This correlation indicated that root number may be important in the uptake of Mg and Ca by orchardgrass plants grown in flooded soils.

Broadsense estimates of heritability were high. Heritability estimates coupled with the range in cation content values indicated that selection progress could be made in the improvement of Mg and Ca content of orchardgrass. Selection for Mg would increase both Mg and Ca, and to a lesser extent, K content.

Selected genotypes were placed into polycross blocks based on high or low levels of cation uptake. Seeds were harvested from these selections and are now being evaluated in an experiment similar to the one described above. The selection of high Mg-containing genotypes and their eventual syntnesis into a cultivar should help alleviate the grass tetany problem from orchardgrass pastures with high soil moisture.

Key words: orchardgrass, *Dactylis glomerata* L., grass tetany, magnesium, hypomagnesemia, flooded soil, broadsense heritability, oxygen.

1-4-1

Spaced Plants in Swards as a Testing Procedure in Grass Breeding

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The grassbreeder likes to observe plants separately and therefore he makes use of wide spacing. A procedure is described in which the plants are spaced in a sward of another grass. In this way the plants can be assessed separately throughout the test, while growing in a dense crop.

When plants are tested under wide spacing in the sward of another species, the differences that exist between plants and between progenies show up earlier and more pronounced than under non-competitive spacing. Plants that are weak performers in the sward, will disappear. When testing timothy (Phleum pratense L.) plants in a sward of perennial ryegrass (Lolium perenne L.) root competition is more important than shoot competition.

The ease of assessment depends on the suppression by the companion crop and on its height and colour. The companion crop has a greater influence on the production level than on the sequence of the objects, the latter not being substantially changed as a rule.

Experimental varieties obtained through selecting perennial ryegrass plants in swards of timothy and of cocksfoot proved to be highly persistent. They showed good regrowth after cutting, with few plants disappearing. As a consequence the sward remained dense and productive. Such a resistance to sward deterioration is very important at high production levels.

Testing plants in swards of another crop is a simple procedure for finding plants that are able to survive and produce in swards and thus promise the continued production desired for perennial grasses. The management is easy and it can be applied at all stages of the breeding scheme to replace or to supplement other ways of testing.

Key words: spacing, competition, breeding, perennial ryegrass, Lolium perenne L., timothy, Phleum pratense L.

1-4-2 Use of Temperature and Moisture Indices to Delineate the Global Adaptation of Two Tropical Pasture Grasses

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The success of pasture development programmes depends to a large extent on the selection of species which are well adapted to the climatic and edaphic environment of the project area.

The objective was to examine the use of temperature and moisture indices to define agroclimatic zones for Rhodes grass (Chloris gayana) and green panic (Panicum maximum var. trichoglume) within Australia and for other countries of the world. No attempt was made to exclude areas within these agroclimatic zones which would be unfavourable because of edaphic and topographic features.

Three moisture and two temperature indices were used to define the boundaries of agroclimatic zones for these grasses.

1. Arid index - Significant species instability occurred when the precipitation/potential evaporation (Thornthwaite estimate) ratio (P/E) in the previous year was less than 0.45 and 0.55 for green panic and Rhodes grass respectively. Because of the variance in annual P/E, values of 0.6 and 0.7 were used to define the arid boundary of adaptation for these species.
2. Humid index - Defined by P/E values of 1.0 and 1.2 for Rhodes grass and green panic respectively.
3. Rainfall distribution index - Defined by the ratio of P for the six warmer to colder months being greater than 1.0.
4. Thermal index - An annual mean thermal index of greater than 0.3 was used to define a suitable thermal environment for these grasses.
5. Frost index - Defined by the minimum temperature for the coldest month of 0 and 3°C for Rhodes grass and green panic respectively.

Global agroclimatic zones were mapped for these species. There was general agreement between this classification of areas of adaptation and an independent assessment of the pastoral potential of these species in Queensland. Significant areas of adaptation were indicated in a number of countries in Central and South America, Asia and Africa. In the tropics, the boundaries were delineated by the arid and humid indices, whilst at high latitudes and altitudes, low temperature and frosts provided additional constraints. Green panic was more widely adapted than Rhodes grass.

The use of these indices to define agroclimatic zones could be extended to other species.

Key words: Panicum maximum var. trichoglume, Chloris gayana, temperature, moisture, global adaptation.

1-4-3 Procedure for Selecting Subterranean Clover Cultivars in Southwestern Australia

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Nineteen cultivars of subterranean clover (Trifolium subterraneum L.) have been registered for use over a wide range of environments in Western Australia. New cultivars are being sought to extend the range of environments in which clover can be grown and to improve on the already established cultivars.

The primary objective is the selection of low oestrogen clovers that are persistent under either a continuous grazing or ley farming system. While low oestrogenicity is achieved by selecting clovers that are low in the isoflavone formononetin, persistency results from the combination of a number of characteristics such as seed yield, hardseededness, tolerance to flooding, disease and insect resistance. Although the particular combination of characters required varies considerably depending on the environment in which the cultivar may ultimately be grown, a five-stage procedure has been developed for general use.

Selection in the first three stages involves the assessment of a large number of introduced and crossbred clovers at two or three locations. Some testing for disease and insect resistance, either in the glasshouse or field, is included. For the final two stages, when the number of clovers may have been reduced to 10-20, selection is undertaken at a number of sites in the intended area of use. Persistency is finally assessed as the maintenance of a high reserve of clover seed, a high clover content in the pasture, and the dense regeneration each year of clover seedlings following cropping and/or grazing.

The characters being selected for in the early stages of the programme can be reliably assessed from undefoliated rows or small swards so allowing large numbers of clovers to be screened. Final selection is undertaken using swards at a number of field sites. Little emphasis is placed on the direct measurement of herbage yield and comparative animal productivity data are not required prior to a cultivar being released for general use.

Five recently released cultivars are being grown successfully over a large area. The new cultivars constitute over one third of the production of certified subterranean clover seed in Western Australia.

Key words: subterranean clover, Trifolium subterraneum L., selection, oestrogens, persistence.

1-4-4 Improving the Efficiency of Forage Crop Breeding

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It is the purpose of this paper to briefly describe ways of improving the efficiency of forage crop breeding. Breeding superior forages requires good germplasm, proper objectives, efficient breeding methods, adequate support, assistance from other disciplines, cooperation with animal science, time and hard work. Methods that reduce the labor and cost per unit of advance will be described. Among them will be recurrent restricted phenotypic selection (RRPS) that quadruples the efficiency of mass selection in improving Pensacola bahiagrass, *Paspalum notatum*, yields; a modification of RRPS for pearl millet, *Pennisetum americanum*, improvement; backcrossing procedures to transfer major genes into pearl millet lines in two years; and four methods of putting the F_1 hybrid on the farm.

Key words: bermudagrass, *Cynodon dactylon*, Pensacola bahiagrass, *Paspalum notatum*, pearl millet, *Pennisetum americanum*.

1-4-5 Improvement of Pollen and Seed Fertility in *Lolium-Festuca* Hybrids

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In order to take the genetic introduction of the desirable characters from other species, *L. multiflorum* and *L. perenne* were crossed with *Festuca*, and F_1 hybrids were backcrossed or tricrossed with five species of *Lolium* and *Festuca*, until the F_4 generation.

F_1 hybrids of *L. multiflorum* x *F. arundinacea* were mostly male sterile, which have only 0.2% - 2.5% stainable pollen, and viable seeds were obtained 0.5% - 2.4% by the backcross or tricross with five species of pollen descended. F_1 hybrids of *L. perenne* x *F. arundinacea* and *L. perenne* x *F. pratensis* were extremely sterile in the pollen and seeds, with rudimental anthers.

Hybrid derivatives from *Festuca* species as the recurrent parents were obligated to keep very low pollen fertilities, less than 0.3%, and viable seeds were also extremely low, 0% - 1.3%, even in the F_4 generation. In contrast, *Lolium*-like hybrid derivatives produced by pollenation with *Lolium* species, enhanced the fertility of pollen and seed according to the generation advanced to the F_4 generation. Sufficient progeny plants were obtained in F_3 and F_4 generations, even when inter-pollenation occurred within hybrid plants.

The fertility of pollen and seed hybrid derivatives varied in accordance with combinations of the backcross and tricross generations. A correlation coefficient, r = 0.802, was obtained between the pollen and seed fertilities. This indicated that higher pollen fertility should lead to the improvement of the seed fertility of hybrids.

From these results, the breeding technique may be considered effective to improve *L. multiflorum* and *L. perenne*. Intergeneric hybrids are backcrossed or tricrossed with *Lolium* species and the high-fertile pollen plants are polycrossed with each other. The progeny plants were then selected for seed fertility and other desirable characters.

Key words: *Lolium multiflorum*, *Festuca arundinacea*, intergeneric hybridization, crossability, pollen fertility, seed fertility.

1-5-1 Selection Effect for Digestibility of Summer Regrowth in Orchardgrass

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Forage digestibility is very important for improving quality through plant breeding. Comparing the second growth and the first growth in a hay and aftermath cutting treatment, reduction in digestibility with delay in date of harvest is smaller and digestibility value is lower. Judging from this and the ease of evaluation and necessity to improve, the second growth is thought to be more suitable for the study of selection. The purpose of this study was to assess selection effect on digestibility of the second growth in orchardgrass.

The values of in vivo digestibility (Y) were predicted by the regression equation: $Y=0.83X+27.68$, where X is the value obtained by the one-step cellulase method.

From 511 plants ranging from 58.0% to 75.4%, 4 high-digestibility (HD) plants and 5 low-digestibility (LD) plants were selected in 1975. Progenies of these two groups were space-planted with their parent plants and evaluated for digestiblity from 1978 until 1979.

Though difference between HD and LD in parents was more than 12% units at the time of selection, the difference reduced to around 5% units in 1978 and in 1979. Furthermore, the difference reduced to 1.5% - 3.3% units in the progenies, but HD was significantly higher than LD. From the results of experiment, realized heritability was estimated as $h_{BN}^2 = 0.48$ and 0.42 in 1978 and 1979 respectively.

Two experimental strains were developed by random pollination of parents in each group in 1976. These strains were compared with 16 other varieties under the management of 3, 4 and 6 annual cuts. HD strain indicated the highest digestibility among all varieties in all three treatments. As an average of three treatments, HD strain was higher by 2.7% units than LD strain. The difference between HD and LD was largest at the harvests in August.

To assess repeatability of digestibility findings, correlation coefficients between years were calculated using 96 individuals of 8 varieties. For the first growth, correlations combined with a certain year were all negative and this is caused by meteorological factors. For the second growth, however, high positive correlations were obtained in all combinations.

An obvious selection effect was observed in this experiment. Concerning dry matter yield, a large proportion is produced in the first growth, so we could not place importance only on the second growth. It is proposed that selection should be conducted for the second growth materials with proposed maturity.

Key words: orchardgrass, *Dactylis glomerata* L., digestibility, cellulase, heritability.

1-5-2 Variation in Nutritive Value in Italian Ryegrass (*Lolium multiflorum* Lam)

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The development of rapid screening techniques has enabled breeders to give cognisance to forage quality as a breeding objective. Italian ryegrass (*Lolium multiflorum* Lam.) is harvested primarily for conservation in the United Kingdom and work at the Welsh Plant Breeding Station is aimed particularly at improving the dry matter digestibility (DMD) of the primary and first regrowth harvests. An assessment of the available variation within the species has shown that material collected in the Po valley region of Italy has consistently higher DMD levels than any other material tested. Our objective was, therefore, to identify the nature of this advantage in DMD and to incorporate it into an agronomically improved variety.

Closely spaced plants and swards of a Po valley ecotype and cv Lemtal, a commercial cultivar, were harvested at four-day intervals for a period of 28 days from the beginning of inflorescence emergence on both the primary and first regrowth harvests in June and July. DMD determinations were then made on the leaf and stem fractions using Pepsin - Cellulase solubility.

Results from both the spaced plant and sward experiments showed little difference in the DMD of the leaf fraction but the DMD of the stem fraction of the Po valley ecotype was significantly higher (4.5 percentage units) than that of cv Lemtal and declined at a slower rate with increasing maturity. Since this species is harvested in Britain when the proportion of stem can be as high as 70%, this increase could represent an important improvement in animal production.

The direct exploitation of this material is restricted by its susceptibility to a number of plant pathogens, generally poor primary growth yields and poor winter hardiness under climatic conditions in Britain. The breeding programme has aimed at improving these deleterious characteristics whilst maintaining any advantage in DMD.

Selection within one ecotype resulted in an improvement in primary growth yields (25%) and total annual yield (6%) while resistance to brown rust (*puccinia recondita*), mildew (*Erysiphe graminis*), and winter damage were significantly improved. There was a small decline in the DMD level (1.5 percentage units) but this was more than compensated for by an increase in dry matter yields of the two important conservation harvests, giving significantly higher levels of digestible dry matter than either the parent population or cv Lemtal. Similar changes in agronomic performance were also achieved by selection in segregating generations deriving from crosses between Po valley material and North European cultivars.

The results indicate important sources of stem DMD which are independent of other characteristics affecting dry matter and so can be utilized for producing new varieties with improved agronomic performance.

Key words: Italian ryegrass, *Lolium multiflorum* Lam, ecotype, dry matter digestibility (DMD), breeding.

1-5-3 Development of a Simple Digestibility Evaluation Method and Its Application to Forage Sorghum Breeding

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For improving digestibility of forage sorghum, the rapid evaluation of the digestion rate and potential values of plant selection should be necessary. The simple cellulase digestion method, in which in vitro dry matter digestibility (IVDMD) of the samples kept almost original form of leaves is determined by one stage technique, has been developed. In this report, the applicability of the simple cellulase digestion method (the SCD method, hereafter) to the evaluation of digestibilities of various sorghums was examined.

IVDMD values of the top fully expanded leaves of each of 22 sorghum cultivars sampled simultaneously at the early heading stage of CK-60 were determined both by the weighing method of the SCD and the two stage Sodium sulfite-cellulase method(Expt. 1). The correlation coefficient between IVDMD values by the above two methods was positively significant(r=0.726***). Sweet Sudan with non-glossy leaf and tan color plant, bmr-18 with brown midrib, bl-Sudan with bloomless trait and Tan GR-5 with tan color plant were selected as the cultivars with high digestibility by the SCD method as well as by the two stage method(Fig. 1). These results suggest that the SCD method would be usable to evaluate the digestibility of the collected cultivars in the selection of the recombination parents with high digestibility.

The top fully expanded leaves of each of 24 sorghum and a corn cultivars were taken simultaneously at each of four leaf stages. Scores and IVDMD values of them were determined by the scoring and weighing methods of the SCD, respectively(Expt. 2). The scores of cultivars at each of the first-to-third sampling times(8th to flag leaf stages) correlated well with each other, and with IVDMD values at each of the first-to-fourth sampling times. F_3-5 8(grain sorghum) with brown midrib and bloomless trait and F_3-2-38^3(sudangrass) with brown midrib and non-glossy leaf were confirmed as lines with high digestibility by the above two methods(Table 1). These suggest that the SCD method would be usable to evaluate the digestibility of the breeding lines in the early generations.

From the above, the SCD method would be applicable to the breeding program of forage sorghum with improved digestibility, and the application of the SCD method to the evaluation of the digestibility both of the collected cultivars in the selection of the recombination parents and of the breeding lines in the early generations is considered to be most effective.

Key words: sorghum, Sorghum bicolor (L.) Moench., digestibility, quality breeding.

1-5-4 Fermentation Potential of Vegetation from Various Herbaceous Plants Following Enzymatic Hydrolysis

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Vegetation from herbaceous plants has been suggested as a possible feedstock for production of liquid fuels. Our objective was to determine the fermentation potential of vegetation from various herbaceous species following enzymatic hydrolysis. Preliminary assessments involved sampling various sorghums (Sorghum bicolor (L.) Moench) and determining the extent of cellulose hydrolysis. Subsequent replicated studies determined cellulose hydrolysis and nonstructural fermentable carbohydrates of brown midrib (bmr) sorghums and their normal counterparts and cellulose conversion rates for a wider range of herbaceous plant species.

Preliminary evidence suggested that enzymatic cellulose hydrolysis could be improved either by use of bmr mutants or by ensiling forage materials. Subsequent studies indicated that rates of cellulose conversion to glucose of bmr mutants were not always superior to those of their normal counterparts even though the lignin content of these mutants was usually lower. Averages from bmr and normal sorghum harvested at two different dates indicated that from 29.4 to 36.5% of the total dry matter could be enzymatically converted to fermentable hexoses. The contribution of nonstructural carbohydrates to the total ranged from 62 to 65%. The unconventional species were substantially higher in lignin content than sorghums, corn (Zea mays L.), and pearl millet (Pennisetum americanum (L.) Leeke). Cellulose hydrolysis of these species ranged from 13.5% of the cellulose present for kochia (Kochia scoparia (L.) Schrad). to 25.8% for Jerusalem artichoke (Helianthus tuberosus L.). The cellulose conversion rates for the grasses ranged from 16.7% for corn harvested at physiological maturity to 30.4% for forage sorghum which was harvested during seed filling.

Variability associated with species, varieties, stage of maturity, and ensiling produced substantial variation in enzymatic cellulose hydrolysis of herbaceous plant vegetation. In addition, quantitative estimates of lignin content were not always associated with the variation observed in cellulose hydrolysis.

Key words: cellulose, enzymatic hydrolysis, fermentable carbohydrates, lignin, Sorghum bicolor (L.) Moench, brown midrib.

1-5-5 Effects of Nitrogen Fertilization, Age of Regrowth, and Cutting Height on King Grass Quality in Cuba

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Effects of nitrogen fertilization, regrowth age and cutting height on quality of king grass (Pennisetum purpureum x P. typhoides) was studied. Treatments were: 0, 200, and 400 kg N/ha/year; 30, 45 and 60 days of regrowth, and 10, 17 and 25 cm cutting height. Crude protein increased with N fertilization up to 13% when 400 kg N was applied but decreased to 5% at 60 days with the same N level. Crude fiber diminished with N level and increased with age; the highest value (38%) was obtained without N fertilization and 60 days, while the lowest (33%) was obtained with 400 kg N and 30 days. In vitro dry matter digestibility increased with N and diminished with age; the highest value (60%) was obtained with 400 kg N and 30 days, while the lowest (36%) was obtained without N and 60 days. Phosphorus and potassium diminished with increasing N levels and regrowth age. Phosphorus varied from 0.26 to 0.56% while potassium varied from 1.08 to 2.38%. Calcium and magnesium showed an irregular relationship to N and age. Crude protein diminished with cutting height. Values of 10.1, 9.9 and 9.2% were obtained when forage was cut at 10, 17 and 25 cm, respectively. Crude fiber showed little variation, fluctuating between 32 and 33.2%. Values for phosphorus (0.40, 0.38 and 0.33%), potassium (2.13, 1.74 and 2.04%) calcium (1.64, 1.48 and 1.62%) and magnesium (0.51, 0.46 and 0.47%) were obtained for 10, 17 and 25 cm cutting height, respectively. In vitro dry matter digestibility diminished to 8 percentage units when forage was cut at 25 cm compared to the 10 cm treatment. The negative effects of increasing age may be improved by applying 400 kg N/ha/year distributed among applications every 45 days and cut between 10 to 17 cm height above the ground level. Also, with these indices an adequate balance in mineral composition was obtained. Factors affecting king grass quality will be discussed and suggestions for further research on this matter will be presented.

Key words: king grass, nitrogen fertilization, cutting height, composition, forage quality.

1-6-1 Acceptability of Tropical Forage Plants: Grasses and Legumes

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The purpose of this study was to compare the acceptability of twenty-five tropical grasses and eight tropical legumes by Zebu cattle. It was conducted at the Estacao in Nova Odessa-SP, Brazil. The relative palatability of the forage species was evaluated by the visual method. They were grazed by four animals in summer and two in winter during two hours each day.

Results: Significant differences (P 0.01) were found among the plants which are listed in descending order of palatability in three classes, as follows:

(a) High: Panicum maximum Jacq., Digitaria valida Stent., Paspalum guenoarum Arech., Brachiaria decumbens Stapf., Panicum maximum Jacq., cv. Gatton panic, Brachiaria Setaria anceps Stapf. cv. Nandi, Chloris gayana kunth. cv. Callide.

(b) Medium: Brachiaria mutica (Forsk) Stapf., Clycine wightii Verdc., Digitaria diversinervis (Ness) Stapf., Pueraria phaseoloides (Roxb.) Benth. var. javanica (Benth) Bak., Digitaria milanjiana (Rendle) Stapf., Macrotyloma axillare (E. Mey) Verdc. Andropogon gayanus Kunth., Digitaria decumbens Stent. cv. Pangola, Digitaria sp., Centrosema pubescens Benth. Echinochloa pyramidalis (Lam.) Hicth & Chase, Glycine wightii Verdc. cv. Cianova, Galactia striata (Jacq) Urb., Cynodon dactylon (L.) Pers. cv. Coast cross., Calopogonium mucunoides Desv., Brachiaria sp., Terammus uncinatus (L.) Sw.

(c) Low: Cenchrus ciliaris L. cv. Biloela, Cynodon dactylon (L.) Pers. cv. Paulista, Paspalum notatum Flugge var. Saurae dactylon (L.) Pers.

Conclusions and significance:

(a) Visual method, observing the animal in pasture during determined times, gave sound indication of the relative acceptability of the plants studied.

(b) Grasses from the genera Panicum and Brachiaria, in general, and species like Digitaria valida, Digitaria sp. (umfolozi), Setaria anceps cv. Nandi, Paspalum guenoarum and Chloris gayana, were highly acceptable to the animals.

(c) Plants from the genera Paspalum (except P. guenoarum), Cynodon, Cenchrus ciliaris and Digitaria sp. (slender) were not very well accepted by the animals.

(d) The forage legumes fell in the middle class of acceptability.

Key words: grasses, legumes, grazing trial, cattle classes of acceptability.

1-6-2 A Comparison Between the In-Vivo Digestibility Value of Normal and Brown Midrib Mutants Grown Under the Cool Climate Conditions of the U.K.

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The brown midrib mutant gene (bm_3) has decreased lignin content and increased digestibility value of whole crop maize silage grown under high ambient temperatures. The aim of the present work was to investigate the effect of the bm_3 gene on the in vivo digestibility values of crops grown under the relatively cool climatic conditions of the UK and where lignin content is already low.

The normal (N) and bm_3 forms of Inra 188, Inra 240 and Inra 258 were grown at the National Institute for Research in Dairying, Reading, and ensiled on 139 days after plant emergence. The six silages were fed to wether sheep at a maintenance level of feeding in a 3 x 2 factorially designed trial, with four sheep/treatment.

The dry matter (DM) content of Inra 188 normal and bm_3, Inra 240 normal and bm_3 and Inra 258 normal and bm_3 silages were 30.4 and 24.6%, 28.3 and 25.6%, and 29.3 and 26.0%, respectively. The mean values for cell wall, acid-detergent fibre, cellulose, hemicellulose and lignin content for the normal and bm_3 silages were 54.8, 21.4, 20.5, 33.4 and 0.88% DM and 52.8, 22.2, 22.2 30.6 and 0.05% DM, respectively.

The results of the in vivo digestibility trial showed that the apparent digestibility of cell walls, acid-detergent fibre, cellulose and hemicellulose was increased from 76.2 to 78.8%, 67.9 to 76.7%, 75.6 to 81.8% and 81.0 to 80.1% (decrease) for Inra 188; from 72.2 to 78.3%, 63.6 to 74.1%, 71.3 to 78.7% and 77.8 to 81.3% for Inra 240;and from 75.8 to 80.6%, 70.3 to 76.8%, 75.8 to 81.9% and 79.6 to 83.2% for Inra 258, by inclusion of the bm_3 gene. The inclusion of bm_3 gene in Inra 188, 240 and 258 increased the digestible organic matter in the dry matter from 73.4 to 76.3%, 71.6 to 74.4% and 76.0 to 77.2%, respectively. With the exception of hemicellulose, where the differences were significant at the 5% level, the increases in digestibility values attributed to the bm_3 gene were all significant at the 0.1% level.

In conclusion, the bm_3 gene has been shown to decrease lignin content and significantly increase the digestibility values of maize genotypes grown under the cool climatic conditions of the UK, where forage and not grain maize production is of primary concern. Further work should be done to compare normal and bm_3 silages at similar stages of maturity and to determine its effect on animal performance.

Key words: maize, brown-midrib-3, digestibility.

1-6-3 **Gliricidia maculata, a Valuable Source of High Protein Green Feed Supplement for Animal Feeding**

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Unavailability of good quality forage is one of the important limiting factors affecting milk production on small farms in Sri Lanka. Gliricidia (Gliricidia maculata) a deep rooted legume plant with high protein content (22-25%) in the dry matter is commonly available in Sri Lanka up to about 1000 m elevation. This species can provide high protein green feed supplement, especially during the feed scarcity periods. Therefore, studies to evaluate Gliricidia were initiated in 1977.

Agronomical studies showed that Gliricidia can be established either with seeds or with mature stems (cuttings). Satisfactory establishment is obtained when stems are at least five months old. Unlike Leucaena, Gliricidia can be grown on very poor acidic soils without any fertilization. Dry matter yields are low in the first two years but yields increase with increasing age of the plant, and annual yields of about 8000-10000 kg/ha can be obtained from a 3-4 year old stand, planted about 30 cm apart in three meter rows. Highest amount of leafy material is obtained when Gliricidia is harvested at intervals of every 3-4 months. Nutritive value of Gliricidia is comparable to that of Leucaena and alfalfa.

Preliminary feeding trials with sheep and cattle indicate that Gliricidia is palatable and can be an excellent source of high protein supplement when fed with poor quality roughage. Gliricidia, when fed with poor quality grass to ewes over a period of two years, gave increased rate of survival and lambing. With milking cows, yield and quality of milk were not affected except that milk was tainted when cows were fed more than 50 percent roughage. In another trial, Gliricidia fed with paddy straw and rice bran to young heifers gave daily mean weight gain of 0.39 kg/animal which was comparable to 0.41 kg gain due to grass and concentrate mixture.

These studies have clearly demonstrated that Gliricidia is a valuable source of protein supplement for animal production in the tropics.

Key words : Gliricidia, Gliricidia maculata, palatability, sheep, survival, lambing.

1-6-4 Cyanogenesis in Dhurrin-Containing Forage Grasses

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Cyanogenesis, the ability of organisms to produce hydrocyanic acid (HCN), has been reported in approximately 1000 species of plants representing 250 genera and 80 families, but the identity of the cyanogenic compound(s) involved has been established for less than 100 of these species. The first cyanogenic compound identified in the grass family was dhurrin, which was isolated from sorghum plants in 1902. Many other grasses were subsequently reported to be cyanophoric, but until recently Sorghum remained the only grass genus in which the presence of dhurrin had been demonstrated unequivocally.

A precise, rapid, and highly specific spectrophotometric assay for dhurrin in seedling leaves was developed at Nebraska in 1977, primarily for use in breeding for low dhurrin content in sudangrass and sorghums. This procedure has been used successfully in selecting sudangrasses with reduced levels of hydrocyanic acid potential (HCN-p). Two cycles of divergent selection for high and low HCN-p in Greenleaf sudangrass have resulted in an average realized heritability of 0.26 and an average broad sense heritability estimate of 0.84. The high- and low-HCN-p populations each differed from Greenleaf by about 20%. Dry matter yields for the high- and low-HCN-p populations, obtained during one growing season after only one cycle of selection, were 7440 and 6680 kg/ha, respectively, compared to 6910 kg/ha for unselected Greenleaf.

The spectrophotometric assay also has been used to screen seedlings of 72 grasses representing 39 species, 14 genera, and 2 tribes for the presence of dhurrin. Among genera other than Sorghum, dhurrin was found only in the genus Sorghastrum. Levels were in the same range as for Sorghum seedlings considered to be high in dhurrin content.

The toxicity of a cyanophoric forage grass is influenced by various factors, one of which is the ability of the animal to detoxify the HCN it encounters. In ruminants, HCN is rapidly detoxified in the rumen and liver by reactions with sulfide or cystine and the resulting thiocyanate is excreted in the urine. The low rates of gain that are sometimes observed when cattle or sheep graze pure stands of sorghum or sudangrass may, in some cases, be explained in terms of an induced sulfur deficiency in the animal due to the priority requirement of sulfur to detoxify HCN. Therefore, sulfur supplements may reduce the potential of HCN poisoning, replace sulfur lost in detoxification of HCN, and insure an adequate dietary level of sulfur for animal needs. Recent studies have shown that released cyanide also may protect animals from the toxic effects of selenium by forming a compound with selenium that is apparently readily excreted in the urine. However, this same reaction may cause selenium deficiency in livestock in areas where selenium levels are low.

Key words: cyanide, prussic acid, HCN, indiangrass, sorghum, sudangrass, selenium, sulfur.

1-6-5 Direct and Indirect Methods of Comparing Indigestibility of Green Forage Grasses

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When the forage plant breeder is to improve ingestibility, f. e., with tall fescue (Festuca arundinacea Schreb.), he needs simple methods of assessing numerous genotypes at a time. Sheep in cages fail to permit such numbers. Two ways are commonly used:

(1) Cafeteria, which implies direct utilisation of animals, giving them free choice. The result is called palatability.

(2) Laboratory indirect methods: chemical analysis, in vitro digestibility, fibrosity index.

None of those methods is able to predict the absolute value of ingestibility, but they are only expected to give the right ranking of the genetic differences between the assessed genotypes.

Correlations have been frequently established between laboratory tests and ingestibility as measured with sheep in cages. Unfortunately, they involved forages differing not only by genotypes but also by other factors: stage of growth, conservation or not, etc. The obtained correlations do not necessarily hold when only genetic differences are to be assessed.

Several types of cafeteria are commonly used by plant breeders. In the present study, we show that 2 cafeterias (grazing in situ and a trough cafeteria) give very similar rankings. Trough cafeteria appears to be a very sensitive, precise and faithful test, provided given conditions are satisfied.

We have also compared palatability through trough cafeteria with "classical" ingestibility and digestibility (through sheep in cages). So far as genetic variation only is concerned, correlation appears to be bal between palatability and ingestibility, but fairly good between palatability and digestibility. Furthermore, there appears no correlation between ingestibility and digestibility, although measured on the same sheep at the same time, whereas palatability and digestibility (positively correlated) are measured on different animals.

Noteworthy, there are indications of ingestibility by dairy goats in free stalling being correlated with palatability and digestibility, but not with ingestibility by sheep in cages.

We are also studying combinations of chemical tests able to explain genetical rankings of palatability (in cafeteria), ingestibility and digestibility (with sheep in cages). In our first experiment, we were able to explain 91% of palatability variance with soluble phenols; 83% of the digestibility variance with a combination of soluble and insoluble phenols; and 50% only of the ingestibility variance with a combination of mono - and polysaccharides.

These results raise an important question: in order to compare ingestibilities of grass varieties for farm animals which have no choice, is the measure with sheep in cages a suitable method? Contrary to farm animals, they have only maintenance needs. The preferences (which can be seen in cafeteria) could play a more important role with producing animals. We shall further investigate this question.

Key words: ingestibility, digestibility, cafeteria, genetic variation, phenols.

1-7-1 Interspecific Hybrids Between Apomictic Forms of *Poa palustris* L x *Poa pratensis* L.

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Kentucky bluegrass has been hybridized with many other *Poa* species during the last years, but interspecific hybrids between fowl bluegrass have not been reported so far. In contrast to most of the other *Poa* species *P. palustris* is like *P. pratensis*, a commercially used forage crop, and we expected better results in such hybrids than in those described earlier. The obligate apomict *P. palustris* was X-irridiated and two-seed-descendent X_2 were grown in the nursery. 47 pairs with different partners were selected and checked for sexuality. One plant with a segregating progeny was used for hybridization. Flowering time of the two *Poa* species differs by about one month and does not overlap. This difficulty was overcome by the storage of the *P. pratensis*-pollen using the method I reported 1970 on the XI International Grassland Congress in Surfers Paradise with a storage temperature of -80°C. Hybridization was done without emasculation on single plants in isolation chambers. In a progeny of 200 plants we found up to 27 hybrids with the *Poa pratensis*, the remainder being pure *P. palustris*.

In 1972 the first hybrids were available. These plants were pure apomicts and stable in multiplication, the interspecific heterosis being fixed in the evolved strains. One strain is a pasture- and lawn-type, another one a meadow-type. Both strains have the subterranean runners of *P. pratensis* and the leaf colour of *P. palustris*. One strain has hairless seeds like the *P. palustris* parent. Disease resistance and yield quality of these strains are much better than those of *P. longifolia* x *P. pratensis* interspecific crosses. Over all, the new hybrids look so promising that one is under registration proceeding in Germany.

Key words: *Poa palustris*, *Poa pratensis*, apomixis interspecific hybrids, mutation.

1-7-2 Improvement of Forage Quality of Tall Fescue Through *Lolium-Festuca* Hybridization

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Annual ryegrass (*Lolium multiflorum* Lam.) x tall fescue (*Festuca arundinacea* Schreb.) hybrid derivatives were used to develop G1-307, an experimental synthetic strain with low perloline alkaloid content and improved succulence and digestibility. Animals consuming G1-307 under high ambient temperature stress exhibited a malady known as "summer syndrome." *Epichloe typhina*, an endophytic fungus of cool-season grasses, was associated with the occurrence of N-acetyl and N-formyl loline (pyrrolizidine) alkaloids in G1-307. The loline alkaloids appeared to be related to the summer syndrome condition. Our objectives were to investigate the variability and heritability of perloline, N-acetyl and N-formyl loline, and the association of *E. typhina* and the lolines.

Twenty-eight parental clones of G1-307, the product of two cycles of recurrent selection for low perloline content and improved succulence and digestibility, were grown in two separate isolated polycross blocks. Clones in one block were untreated and those in a second block were previously treated with benomyl, a systemic fungicide, for at least 10 days in a 1:1000 benomyl:soil mixture in a greenhouse in an effort to remove *E. typhina* from the clones before transplanting them to the field.

Polycross progenies of untreated clones, the G1-307 strain, and commercial cultivars were evaluated for perloline content in replicated sod plots arranged in a randomized block design. Equal amounts of seed of each clone of treated and untreated blocks were blended to form G1-307 strain. Seeds of the G1-30 (treated) and G1-307 (untreated) were used to establish 2.2 and 3.3 ha swards, respectively.

Means of untreated parental clones and polycross progenies (pcp) differed significantly for perloline, N-acetyl and N-formyl loline content. Broad sense heritability estimates using parental variance of perloline, N-acetyl and N-formyl loline were 0.88, 0.67, and 0.76, respectively, and 0.50, 0.33, and 0.79, respectively, when using pcp variance. Narrow sense heritability estimates for perloline, N-acetyl and N-formyl loline content were 0.45, 0.54, and 0.91, respectively. Infection by *E. typhina* and content of pyrrolizidine alkaloids were reduced 71.5 and 67.9%, respectively, when parental clones were treated with benomyl. Hay from swards established from seed of benomyl-treated and nontreated clones had pyrrolizidine alkaloid levels of 115 and 875 µg/g and infection estimates by *E. typhina* of 44 and 95%, respectively. Young cattle under high ambient temperature stress (32 C) when fed hay containing 115 µg/g lolines did not have "summer syndrome" symptoms, and had significantly better feed intake and performance than those receiving G1-307 hay containing 875 µg/g lolines.

Key words: alkaloids, perloline, N-acetyl and N-forml lolines, digestibility, succulence, heritability, summer syndrome, *Epichloe typhina*, animal performance.

I-7-3 Potential of Interspecific Hybridization in Pennisetum

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The objectives of this research were to (1) produce high-quality and high-yielding interspecific forage hybrids and (2) utilize germplasm from related Pennisetum species to improve pearl millet, P. americanum.

Interspecific hybrids were made by pollinating pearl millet with P. purpureum, P. setaceum, and P. orientale. P. purpureum x pearl millet crosses were also made. Fertility was induced in the sterile triploid pearl millet x P. purpureum interspecific hybrids by doubling the chromosome number to produce the amphidiploids. Agronomic characteristics were evaluated in replicated field trials.

Pearl millet x P. purpureum hybrids (3x = 21) produce high-quality late-season forage, are pest resistant, and are perennial. The best interspecific hybrids produced 35% more dry matter and were equal in in vitro dry matter digestibility and protein to the best pearl millet hybrids. The interspecific hybrids can be seeded or vegetatively propagated. There was no agronomic advantage of the hexaploids (6x = 42) over the triploids other than fertility which allowed for backcrossing to pearl millet for the transfer of germplasm. Pearl millet x hexaploid (6x = 42) backcrosses have resulted in the transfer of restorer genes and genes for inflorescence type. Much potential exists for transferring genes for pest resistance, perennial growth habit, yield, and other agronomic characteristics.

Preliminary observations indicate that the P. purpureum x pearl millet crosses have more cold tolerance than the reciprocal cross, indicating a cytoplasmic effect. Amphidiploids (6x) of P. purpureum x pearl millet have been induced for the purpose of transferring P. purpureum cytoplasm into pearl millet. The P. purpureum cytoplasm in pearl millet will also be tested for its effects on new sources of cytoplasmic-genic male sterility and other agronomic characteristics.

The pearl millet x P. setaceum and P. orientale hybrids were apomictic like the male parents, indicating that apomixis is dominant. The interspecific hybrids have no agronomic potential but are an important bridge in the interspecific transfer of germplasm. Once fertility is induced through amphidiploidy in these hybrids, then there is a good chance that apomixis as well as pest resistance, drought tolerance, etc. can be transferred to pearl millet (a sexual species) by using radiation of pollen to produce translocations between the genomes and backcrossing to pearl millet.

Key words: pearl millet, Pennisetum americanum, Pennisetum setaceum, Pennisetum orientale, apomixis, hexaploids, amphidiploids.

1-7-4 Breeding of Apomictic *Eragrostis curvula*

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Eragrostis curvula (Schrad.) Nees and related species are important pasture and range forage plants in the semi-arid and arid southwestern United States of America. Types within these polymorphic, apomictic species have different adaptations and characteristics. Breeding cultivars with new combinations of characteristics should increase greatly their usefulness. Our objectives were to determine the relationship between data from cytological studies of hybrids and from progeny test classifications of mode of reproduction, to evaluate mode of reproduction in lovegrass hybrids, and to develop an efficient breeding scheme. In general, results of cytological analysis of megasporogenesis and embryo sac development and spaced-plant tests of progeny variability gave similar evaluations of mode of reproduction. Results indicated that 40% of hybrids were predominantly apomictic, 20% were intermediate, and 40% were predominantly sexual in tetraploid sexual X tetraploid apomict crosses. In crosses of tetraploid sexual X one octaploid apomict, 90% of the hybrids were predominantly apomictic. We propose a breeding scheme using sexual X apomict hybridization to produce apomictic cultivars.

Key words: weeping lovegrass, lehmann lovegrass, *Eragrostis lehmanniana* Nees, mode of reproduction, diplospory, hybrids, cytology, progeny, breeding scheme.

1-7-5 Use of Embryo Culture with Nurse Endosperm for Interspecific Hybridization in Pasture Legumes

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Future progress in the breeding of pasture plants will depend on use of base populations with maximum variation. This applies particularly to extension of species into marginal areas. Interspecific hybridisation offers one possibility of extending the range of variability beyond that offered by a single species.

These principles have been applied successfully to the forage legume genera : *Trifolium*, *Ornithopus* and *Lotus*. A technique of *in vitro* embryo culture has been developed to overcome endosperm failure after interspecific pollination. This technique involves sterile culture of a hybrid embryo after transplantation into a nurse endosperm dissected from a normal ovule.

Materials produced include *Trifolium ambiguum* x *T. repens*, *T. ambiguum* x *T. hybridum*, *T. repens* x *T. uniflorum*, *Ornithopus sativus* x *O. compressus*, *O. pinnatus* x *O. sativus*, and *Lotus pedunculatus* x *L. corniculatus*.

The hybrids *O. sativus* x *O. compressus*, and *L. pedunculatus* x *L. corniculatus* are fully fertile in advanced generations and show good agronomic potential. *T. ambiguum* x *T. repens* and *T. repens* x *T. uniflorum* hybrids are partially fertile and are likely to respond to selection for increased fertility. *O. pinnatus* x *O. sativus* hybrids are fertile but require embryo culture to overcome defective endosperm development. The cross *T. ambiguum* x *T. hybridum* has so far given completely sterile progeny.

A feature of the embryo culture technique using nurse endosperm is the high success rate for hybrids obtained. Although hybrid numbers are small they arose from no more than a few hundred flowers pollinated and generally fewer than 100 putative hybrid embryos cultured. Therefore it is concluded that prospects for large scale application of this method are very great.

Key words: interspecific hybridisation, nurse endosperm, embryo culture, white clover, *Trifolium repens* L., *Trifolium ambiguum* M. Bieb., Alsike clover, *Trifolium hybridum* L., *Ornithopus sativus* Brot., Serradella, *Ornithopus compressus*, *Ornithopus pinnatus* (Mill.) Druce, *Lotus pedunculatus* Cav., *Lotus corniculatus* L., *Trifolium uniflorum* L.

1-8-1 Differential Interspecific Compatabilities Among Genotypes of *Trifolium sarosiense* and *T. pratense*

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Interspecific compatibilities were investigated among genotypes of *Trifolium sarosiense* Hazsl. used as females and *T. pratense* L. (red clover) used as males. This research was undertaken to introduce perenniality of *T. sarosiense* into *T. pratense* by hybridization and thus increase the longevity of stands of red clover for hay, pasture, and soil improvement. Objectives of the study were to further the knowledge of interspecific hybridization barriers in *Trifolium*, and to isolate clones of *T. sarosiense* and *T. pratense* which could aid in their eventual hybridization, either directly or by embryo rescue.

Twenty-three clones of *T. sarosiense* were used as females to cross with eight clones of *T. pratense* as males. Plants were maintained in a growth chamber at 15-18°C and at a photoperiod of 16 hours, so that all plants flowered continuously for 3 years. Seeds were dissected from pods and visually classified into four categories of seed size. Class I seeds were largest and based on grow-out tests were considered to be selfs.

Parental genotypes were significantly different in seed set, but no combination produced hybrid seeds that would germinate *in vivo*. *T. sarosiense* X *T. pratense* interaction effects, while significant, were not as important as the female effects.

T. sarosiense and *T. pratense* clones that produced relatively large amounts of class II hybrid seeds (the largest) also tended to produce the largest amounts of class III seeds (the next largest), but did not often produce large amounts of class IV seeds (the smallest). It was inferred that production of class II and III shriveled seeds was of greater importance than production of class IV seeds. Class II and III embryos, although not capable of germinating in vivo, were capable of being rescued via tissue culture because of their delayed abortion.

Recurrent selection for viable seeds probably would be effective for interspecific hybridization. In the present hybrid, however, recurrent selection is not necessary since embryos are being produced which are sufficiently developed for rescue by tissue culture.

Key words: red clover, perenniality, hybridization, embryo rescue.

1-8-2 Successful Hybridization of Red Clover with Perennial Trifolium Species via Embryo Rescue

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The objective of this research was to hybridize long-lived perennial *Trifolium* species with the agronomically desirable forage species red clover (*Trifolium pratense* L.). Numerous previous attempts to hybridize red clover with perennial *Trifolium* species using conventional crossing procedures have been unsuccessful. In the present research, *in vitro* embryo culture methods were used to facilitate the recovery and growth of hybrid embryos prior to *in situ* embryo abortion. The major effort was directed toward the cross of T. sarosiense Hazsl. with red clover. Preliminary efforts have been made to cross zigzag clover (T. medium L.) and T. alpestre L. with red clover.

Crosses were made with the perennial species serving as female parents. Embryos were dissected aseptically from pollinated florets at 12-19 days after the crosses were made. The immature embryos, principally heart stage, were cultured on agar-solidified nutrient media modified from that developed previously for tissue and cell cultures of red clover. The initial culture period was for 8-14 days on a medium containing a high concentration of sucrose, a moderate level of auxin, and a low cytokinin activity. The high level of sucrose used prevented precocious germination of radicles from the embryos, and the levels of growth regulators used allowed for the maturation of the embryos. Embryos which survived this culture treatment were transferred to a medium with low auxin and moderate cytokinin levels, which encouraged shoot germination. Hybrid shoot numbers were increased on a low auxin-high cytokinin medium, and subsequently rooted before transfer to soil in the greenhouse.

Numerous hybrid plants have been obtained from the cross T. sarosiense x T. pratense. About 10% of the cultured embryos were rescued on the optimal culture sequence. Five F_1 lines of the hybrid were grown successfully to maturity. Rescued plants were verified to be hybrid on the bases of cytological, genetical, and biochemical evidences. Of interest, the rhizomatous root habit of the perennial parent was expressed in the hybrid. Preliminary efforts with the crosses of T. medium and T. alpestre with red clover have produced a few plants using the same methods, but verifications have not been performed.

The embryo rescue procedures utilized in these studies have produced the first successful, verified cross of a perennial *Trifolium* species with red clover. These procedures should be useful for producing other interspecific hybrids of red clover. The transfer of genes for the perennial character to red clover from interspecific hybrids would be of great value in the efficient production of red clover by improving field persistence.

Key words: red clover, persistence, *Trifolium*, hybridization, *in vitro*, embryo rescue.

1-8-3

Phylogenetic Investigations of Apomictic *Paspalum dilatatum* and Related Species

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Common dallisgrass, *Paspalum dilatatum* Poir, is an important forage grass throughout much of the warmer regions of the world including the southern United States of America. Apomixis has been an important factor in the origin and preservation of this species. It is a 50-chromosome natural hybrid with 3 genomes which pair as 20 bivalents and 10 univalents at meiosis. Because it is a pentaploid obligate apomict, plant breeders have been unsuccessful in improving this species. The apomictic barrier has not been altered by radiation or interspecific hybridization. In an effort to circumvent this apomictic barrier, a phylogenetic investigation was initiated to identify its progenitors, to eventually resynthesize the species, and to allow breeding progress. A sexual tetraploid, yellow-anthered biotype is closely related to common dallisgrass and its chromosomes are homologous with 40 chromosomes of common dallisgrass. The yellow-anthered biotype was used as a cytological substitute for common in the phylogenetic program and was crossed with other *Paspalum* species. Two diploid species, *P. intermedium* Munro. ex. Morong and *P. jurgensii* Hackel, have genomes homologous with a yellow-anthered dallisgrass genome. The genome formulas II, JJ, and II JJ have been assigned to *P. intermedium*, *P. jurgensii*, and yellow-anthered dallisgrass, respectively. Findings to date indicate that *P. intermedium* and *P. jurgensii* or closely related species are the ancestors of yellow-anthered dallisgrass. Information from hybrids involving other species indicates the I and J genomes are widespread in the genus. One or both of the genomes or evolved forms have been identified in species of the Dilatata, Paniculata, Quadrifaria, and Virgata groups but are absent in the Disticha, Notata, and Setacea groups. Common dallisgrass has the genome formula II JJ X where X is an unknown genome. It was proposed that the grass originated from a cross between a sexual tetraploid with the genome constitution II JJ and an apomictic hexaploid II JJ XX. Efforts are underway to identify the hexaploid species.

Key words: common dallisgrass, yellow-anthered dallisgrass, *Paspalum intermedium*, *P. jurgensii*, chromosome pairing, interspecific hybrids, genomes, species relationships.

1-8-4

Cytology and Breeding Behavior of Cicer Milkvetch

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Microsporocytes from plants of cicer milkvetch (Astragalus cicer L.) showed a variable but relatively low frequency of multivalents at first metaphase of meiosis. Meiotic irregularities that are associated with multivalent synapsis, including univalents at first metaphase, lagging chromosomes and dividing univalents at first and second anaphase, were observed also. The relatively low incidence of these events indicates that they are an improbable source of significant genotypic instability, infertility, or phenotypic variation in this species. More significant and impressive is the degree of diploidization that has occurred and the essential regularity of meiosis that this confers.

The polyploid nature of cicer milkvetch is itself a potential buffer against the phenotypic consequences of meiotic irregularities. Aneuploidy for single chromosomes characteristically involves loss or gain of single homologues of a group actually or potentially involved in the formation of quadrivalents. Hence, genetic effects of such gain or loss are minimized by the genetic redundancy consequent on the quadriplex condition.

Cicer milkvetch is probably an autoallooctoploid that has been diploidized by natural selection. Four of its constituent genomes are homologous as evidenced by the formation of quadrivalents. Homologies of the other four genomes are uncertain. Available evidence favors the hypothesis that cicer milkvetch is a trigenomic autoalloploid (AAAABBCC) in which homologues from two of the three genome-types pair preferentially to form bivalents.

Key words: cicer milkvetch, Astragalus cicer L., meiosis, multivalents, meiotic irregularities, autoallooctoploidy.

1-8-5

Successful Incubation of Alfalfa (*Medicago sativa* L.) Pollen Plants

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The induction of alfalfa anther callus, as well as its differentiation into plantlets, has been investigated. The results showed that the anthers of 4 varieties of alfalfa were successfully cultured *in vitro*, when those with uninucleate pollen grains were innoculated on the basic medium N 6. 486 calluses were induced from 4540 anthers, the successful percentage being 10.7. 971 green plantlets were differentiated from anther callus, the differentiate frequency of anther callus being 20.6%. 733 plantlets got rootlets and 238 plantlets had no rootlets. The percentage of root formation was 75.4%. 180 plants were viable. The plantlets' rootlets have been transported in the soil, the root developed and the plantlets may be viable.

Among the 4 varieties tested, the local variety of Long-Mu No. 1 was superior. 126 green plantlets were differentiated from callus No. 61. 30 plantlets were viable, but 5 of the plants were sterile.

Cytological observation showed that the chromosome number of the root tip cell was 16, showing haploid. That haploid plants were derived from pollen grains was proved.

Key words: successful incubation, alfalfa, pollen plants.

1-9-1 Differences in Photosynthetic Types in the Laxa Group of the *Panicum* Genus: Cytenogenetics and Reproduction

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Several grass species related to *Panicum milioides* Nees ex Trin., a species with intermediate photosynthetic characteristics, were collected in South America. *Panicum prionitis* Griseb. was found to possess C_4 photosynthesis. *Panicum schenckii* Hack. and *Panicum decipiens* Nees ex Trin. were found to have intermediate photosynthesis like *P. milioides*. *Panicum laxum* Sw, *Panicum hylaecium* Mez., and *Panicum rivulare* Trin. were all found to have C_3 photosynthesis. In this study, we describe the cytogenetic and reproductive characteristics of these species for future studies of hybridizations among distinct photosynthetic types.

A basic chromosome number of 10 was common for all species. Diploid (2n=2x=20), tetraploid (2n=4x=40), and hexaploid (2n=6x=60) accessions were found. *P. prionitis* possessed a diploid and tetraploid accession. *P. milioides* was diploid, *P. schenckii* was hexaploid, and *P. decipiens* exhibited one diploid and one hexaploid accession. *P. laxum*, *P. hylaeicum*, and *P. rivulare* were all tetraploid. There was stable and primarily bivalent pairing at metaphase I in all species which resulted in a high percentage of stainable pollen. Embryo sac analyses showed normal sexual development in all plants except one accession of *P. prionitis* which was found to possess multiple embryo sacs at anthesis. Self -pollinated seed set was high in all species.

An intraspecific hybrid resulted from a cross of two *P. laxum* accessions. Although this hybrid possessed more tetravalent pairing than either of its parents, it did produce a great deal of viable pollen and seed.

The similiar and stable cytogenetic characteristics, as well as similiar taxonomy, indicate possible success in producing hybrids among these species for a genetic study of photosynthetic characteristics in grasses.

Key words: Embryo sac analysis, C_3, C_4, and intermediate photosynthesis.

1-9-2

Breeding *Cenchrus ciliaris* and Other Apomictic Grasses

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Efforts to breed apomictic grasses met with little success in the past but results of more recent research show progress in some species and exciting new prospects for improving apomicts. Early research explained the cytological basis for apospory and diplospory, the common apomictic mechanisms in grasses, and showed that apomixis is transmitted from parent to offspring. Discovery of sexual or partially sexual (facultative apomicts) plants in several species allowed for hybridization and subsequent genetic studies. Research with several species confirmed inheritance of apomixis and data from most studies indicated that method of reproduction was simply inherited and probably controlled by no more than two genes.

Demonstration of control and manipulation of obligate apomixis through hybridization of sexual and apomictic plants and production of true-breeding hybrids established the potential of using apomixis in a breeding program. Soon thereafter obligate apomictic hybrid cultivars were developed for commercial use. Reports of progress in the breeding of some facultative apomicts is considered very significant. Contrary to some earlier contentions, scientists found that highly apomictic hybrids can be recovered following hybridization of plants capable of both apomictic and sexual reproduction. Efforts to improve *Cenchrus ciliaris*, *Eragrostis curvula* and *Paspalum dilatatum* are discussed.

Key words: buffelgrass, apospory, diplospory, obligate apomixis, facultative apomixis, method of reproduction.

1-9-3 Genetics and Utilization of Apomixis for the Improvement of Guinea Grass (Panicum maximum Jacq.)

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Natural polymorphism in Guinea grass (Panicum maximum Jacq.) has been stabilized in tetraploid biotypes by apomixis. Sexual diploids were found in East African populations. Our objective was to determine whether apomixis could be related with a simple genetic background and manipulated in an improvement program.

Apomicts of Guinea grass are characterized by a 4-nucleate embryo sac structure, and this trait was used in genetical analyses to differentiate apomictic from sexual hybrids. Progeny tests were also conducted as controls.

Ten different types of progenies were analyzed: tetraploid sexual (from colchicine treatment of diploids) x apomictic F1 hybrids, selfed and back crossed progenies of sexual F1 hybrids, three-way hybrids combining informations from one sexual and two different apomicts, selfed and back crossed progenies of sexual three-way, sib mating progenies (crosses between sexual hybrids or sex x apo combinations), test crossed progenies and selfed progenies of facultative apomicts.

All the data fit with a single gene model for the inheritance of apomixis, in which the sexual diploids would have the genotype aa, and the apomictic tetraploids the genotype Aaaa. Apomixis is dominant.

Apomixis in Panicum maximum is often facultative, but with a low percentage of residual sexuality. Eighty natural apomicts and eighty apomictic hybrids have been compared, to show that this rate of sexuality remains low following hybridization.

According to these cytogenetical and embryological studies, along with other data from plant evolution studies, an improvement scheme has been drawn and successfully tested. From each cross combination one half of the hybrids are apomicts which can be immediately propagated by means of seeds if they are found to be promising.

We have conclusively demonstrated that apomixis could be simply manipulated in an improvement program. Different hybrids adapted to the humid tropical lowlands of West Africa have been selected. The conservation of a large germplasm of Guinea grass and related species has also been realized.

Key words: Guinea grass, Ranicum maximum, apomixis, embryo sac analysis, crop improvement.

1-9-4 Hybridization in Andropogon gayanus - A. Tectorum (Gramineae) Complex: Potential for Pasture Improvement

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Andropogon gayanus Kunth. and A. tectorum Schum. and Thonn. are very important natural fodder grasses in Nigeria. While A. gayanus occupies dry habitats and is usually hairy, A. tectorum prefers wetter and moderately shaded areas, is generally glabrous and possesses broader leaves. The primary aim of this work is the production of superior hybrids which would combine desired agronomic traits usually distinctive to either species.

Hybridization was carried out by controlled crosses and open pollination involving collections of A. gayanus (2n=40) and A. tectorum (2n =20). Hybrids were identified by their exhibition of intermediacy in certain morphological features and by meiotic and mitotic chromosome analyses.

Forty-three interspecific triploid F1 hybrids (2n=30) and one aneuploid hybrid (2n=33) were obtained. One hybrid was highly pollen-fertile (92.17%) and seed-set was very high. Others showed varying degrees of pollen sterility (0.63-17.46%) and low seed-set. Hybrid vigour, and the early regrowth and protracted vegetative growth associated with some A. gayanus clones were observed in most hybrids.

One of the greatest challenges facing forage research in Nigeria is the fact that most natural fodder grasses attain maximum growth within a few months in the year. Consequently, fresh pasture is unavailable for nearly throughout the dry season. The selection of hybrids which combine hybrid vigour with the early regrowth and high palatability features of A. gayanus (for example), could prove a great asset to the forage industry. The ease with which the hybrids were obtained and the fertility of some points to possibilities of natural hybridization and introgression between these species in grasslands where they coexist.

Hybridization between some species of Andropogon has thus been shown to be feasible and holds a lot of promise as a means of improving the quality of pasture.

Key words: Andropogon Gayanus Kunth., A. Tectorum Schum and Thonn., hybrids, vigour, pasture.

1-9-5 Ecotypic Differentiation in TAil Fescue

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Tall fescue (Festuca arundinacea Schreb., 2n = 6x = 42) is a widely adapted forage species which grows in various climatic, edaphic and geographic regimes. As a result of growing in different eco-geographical habitats, this grass has developed several ecotypes. Although these geographically isolated ecotypes are morphologically similar, have the same chromosome number, and are rather easily crossable, some of them are reproductively isolated as evidenced by the complete sterility of their hybrids.

To elucidate the cytogenetic basis of this reproductive isolation, geographically isolated ecotypes from different parts of the world were crossed in all possible combinations. Parental ecotypes and their hybrid families (including some reciprocals) were studied with respect to their meiotic pairing and pollen fertility. All parental ecotypes showed regular meiosis with the formation of 21 bivalents. Hybrids between some ecotypes, particularly those with the same geographical distribution, also had regular meiosis and were fertile. However, in certain crosses between geographically isolated ecotypes, hybrids had extremely irregular meiosis with numerous multivalents and/or univalents; consequently, they were completely sterile. Thus, hybrids between north European (or north American) and north African ecotypes were meiotically irregular and sterile.

Detailed studies showed that extensive multivalent formation resulting in hybrid sterility is not due to translocation heterozygosity of the parental ecotypes. However, it is due to breakdown in the hybrids of the regulatory mechanism which controls diploid-like chromosome pairing in the parental ecotypes. Genetic interaction between some geographically diverse ecotypes leads to the inactivation of the diploidizing mechanism, resulting in extensive homologous pairing (multivalent formation) and complete sterility. This is a novel and unprecedented method for the creation of reproductive isolation barriers between ecotypes of the same species. The cytogenetic, phylogenetic and breeding implications of this unique reproductive isolation mechanism are discussed.

Key words: tall fescue, chromosome pairing, ecotypes, reproductive isolation.

1-10-1

Preliminary Evaluation of Legume Germplasm in the Cerrados of Brazil

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The Cerrados of the center-west region of Brazil occupy 180 million hectares and are classified as well-drained, tropical savannas. The Brazilian cattle population numbers 110 million and almost 40 percent is found in the Cerrados. To improve the nutrition of the grazing animal, attention has been focused on cultivated pasture species, particularly tropical legumes. None of the commercial legume cultivars (mainly Australian) can be recommended for large areas of the Cerrados. Those of species such as siratro (Macroptilium atropurpureum (DC.) Urb.) and leucaena (Leucaena leucocephala (Lam.) De Wit) are not adapted to these acid, infertile soils with a high aluminum content, whilst Stylosanthes Sw. species are highly susceptible to the fungal disease anthracnose (Colletotrichum gloeosporioides Penz.).

In 1978 an evaluation program was initiated to select legumes that (i) grow and produce seed on acid soils under aluminum and water stress, (ii) persist under grazing and (iii) tolerate pests and diseases. The work is being conducted at the Cerrados Agricultural Research Center, near Brasilia at latitude 15° south and altitude 1000 to 1100 m. Rainfall is 1578 mm, mostly distributed in a six month wet season, and mean annual temperature 21°C. 680 legume accessions from 13 genera have been established as spaced plants on the two major soil types of the region. The pH of the soils is 4.6, with aluminum saturation in excess of 60 percent. Known nutrient deficiencies were corrected. Results are reported for 352 of the accessions over a two-year period.

The most promising genus is Stylosanthes. 17 accessions of S. guianensis (Aubl.) Sw., S. capitata Vog., S. scabra Vog. and S. viscosa Sw. have combined good adaptation to acid soil conditions and good tolerance to pests and diseases. All S. guianensis accessions belong to a distinctive group of fine-stemmed, highly viscous ecotypes presently referred to as the "tardio" group. Their outstanding attribute is tolerance to anthracnose, the major limiting factor to the use of the genus in the region. Seed of the selected accessions is being multiplied and observations will continue for a further two years before promising accessions enter the second stage of the program for evaluation under grazing. The number of accessions of Stylosanthes has been increased further within the program.

None of the other genera have shown the potential of the genus Stylosanthes. New Calopogonium Desv. and Galactia P.Br. accessions were no more productive than commercial control cultivars. Aeschynomene L. accessions were highly susceptible to anthracnose whilst those of Pueraria, DC., Teramnus P.Br., Vigna Savi and Centrosema (DC.) Benth. species grew relatively poorly. Zornia J.F. Gmel. accessions were very vigorous but all plants were very susceptible to an insect-virus-fungus complex. Tolerance has been found in new ecotypes of Z. brasiliensis Vog. Most Desmodium Desv. species showed poor vigor and were affected by the disease "little-leaf mycoplasm". Observations are continuing with these other genera but introductions are being made on a more limited scale.

Key words: savannas, cerrados, Brazil, anthracnose, Colletotrichum gloeosporioides Penz., Stylosanthes, adaptation.

1-10-2

Introduction and Utilization of Three Fine Legumes in China

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China has a vast territory with extremely varied climate, soil and topography and is very rich in pasture grass resources. This article deals with the introduction and utilization of three fine legumes.

1. Alfalfa (Medicago sativa L.)

China has a history of 2,000 years in the cultivation of alfalfa. The total area now is about 6 million Mu (1 Mu = 1/15 hectare), highest in area of planted grasses. Alfalfa is distributed in more than ten provinces located 35°-45° north latitude. It is adapted to growth in those areas where the annual mean temperature is 5°-12°C, the annual accumulated temperature is 2,700°-5,000°C (above 0°C) and the annual rainfall is about 400-600 mm. It is not easy to survive the winter in those areas where the annual mean temperature is below 5°C.

2. Yellow alfalfa (Medicago falcata L.)

M. Falcata is tolerant to low temperature and can survive the winter safely under the low temperature in the northern part of the Neimenggu Autonomous Region and Heilongjiang Province. Furthermore, it can be used as parent material for alfalfa breeding.

3. Shadawang (Astragalus adsurgens Pall.)

Shadawang is a perennial legume. After introduction and domestication of its wild variety, 50,000 Mu of Astragalus adsurgens has been planted in recent years in the areas located between 33°-43° north latitude. It is tolerant of cold weather, drought, and poor soil, and is resistant to wind erosion and desertification. Aerial seeding on the loess plateau in the Northwest of our country has been successful. Astragalus adsurgens is adapted to those areas where the annual rainfall is about 300-500 mm. But Astragalus adsurgens could not bear fruits or bear very few fruits in those areas where the annual mean temperature is below 8°C, the annual accumulated temperature is below 3,600°C (above 0°C) and the frost-free period is less than 150 days.

Key words: legume, introduction, utilization, adaptability, distribution.

1-10-3 Hedysarum mongolicum -- An Important Protein Resource Legume on Dry Sandy Land

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To improve dry and poor sandy land with legumes has been recognized as very difficult work, because annual rainfall is usually less than 300 mm in the sandy areas. Under unirrigated conditions some crops of legumes and grasses do not adapt and grow.

Hedysarum mongolicum is a perennial sub-brush legume, one of the sweetvetch genus plants. The Chinese name is Youngchea, which means "sheep like to eat." It can grow well in stable or sub-stable sand dune areas. In favorable growing conditions the main stems reach a height of 100-150 cm and the plant canopy is generally 100-150 cm in diameter.

Native seeds of H. mongolicum were collected and planted as vegetative material in the Maowusu desert from 1957 to 1964. We made the studies of the H. mongolicum species distribution, wild seed characters, biological features, and nutritional evolution.

The sweetvetch Youngchea is being expanded in some areas of Inner Mongolia; their successful experience was in the county of Chingsyahe, where 2000 ha have been planted by peasants. The nutritive value and some amino acids were analyzed.

Sweetvetch Younchea has a long tap root. It may be 2 m in depth. Below the crown several buds of creeping-roots shoot. The strong rhizomatens branches will grow 5-6 m long, along the sandy soil 20-30 cm below the surface. We have investigated the development of the root system of Youngchea in native sand dune. The creeping-roots of an individual plant expand 30 sq. m. and their total length is 108 m. The shoots above the ground have 81 clumps; they look like a vast vegetative cover.

Seed coats of Youngchea are impermeable to water. The seed should be properly scarified before seeding. In the county of Chinsyahe early spring seedings usually are more successful than late summer seedings. During the first year few flowers bloom; the plants grow only nutritional branches. In the second year they begin to flower. Beautiful aspects on the yellow sand are formed by purple-red flowers and green bushes in July and August. The annual yield of hay reaches 4500 kg/ha, the harvesting seeds 100 kg/ha.

Youngchea is a high protein plant. Its crude protein contents of all dry matter is more than 20% in the flowering phase. Several amino acid contents are greater than grades of dehydrated alfalfa. This Youngchea for hay is very good; most animals like to eat it in winter. It is adapted to improve sandy land and to establish legume-based pastures on dry steppe land. Many seed production regions are established in Inner Mongolia.

Key words: sweetvetch, Hedysarum mongolicum, legume, protein, resource, dry, sandy, land.

1-10-4 A Morphological Analysis of Old Alfalfa Populations in North Dakota Rangeland

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Objectives of this study were to determine the magnitude and general direction of introgression in heterogeneous Medicago sativa L.-Medicago falcata L. alfalfa populations from semi-arid rangeland and to evaluate inter- and intra-site variation. Leaf size and shape, plant size, flower color, and pod shape were investigated on 2,750 plants randomly selected from nine sites located near Mandan, North Dakota, USA. Sites consisted of: three tests of M. falcata and M. sativa abandoned many years ago; three sites with escaped plants in uncultivated rangeland; two old abandoned alfalfa nurseries containing both M. falcata and M. sativa; one site on a terraced hill, planted to a mixture of M. sativa and M. falcata. Sites of known age were from 22-42 years old. Exact age of escaped alfalfa in native range is unknown, but in one instance it came from a 25-year-old abandoned planting.

A high proportion of M. falcata traits occurred on all sites, but the proportion of M. falcata and M. sativa traits varied among sites. For example, on two adjoining sites, originating from the same seed source, M. falcata shaped leaves occurred 57 percent of the time on site 1 and 67 percent of the time on site 2. M. falcata pod shapes occurred 57 and 77 percent of the time, respectively, while M. falcata flower color occurred 27 and 77 percent of the time on site 1 and site 2, respectively.

A wide range in flower color indicated that introgression was still progressing and that alfalfa was reseeding itself. Very large old plants were also found, indicating that the populations contained genotypes with extreme longevity.

Only 25 of 1,148 genotypes selected from these sites for transplanting had vegetative root proliferations after three years growth. Seven were from one site and were predominantly yellow flowered, while 18 were from another site and were predominantly purple flowered. The 18 came from early plantings of creeping alfalfa from Swift Current, Saskatchewan, Canada. The seven yellow flowered creeping alfalfas probably trace back to alfalfas brought in by the early plant explorer N. E. Hansen.

These findings suggest that when M. falcata and M. sativa are interplanted into North Dakota rangeland, yellow flowered M. falcata persists as well or better than common M. sativa. M. falcata deserves more consideration than previously given by breeders of rangeland alfalfas. The low frequency of creeping genotypes may only reflect their proportion in the original population. However, it is obvious that at Mandan, unless heavily grazed, the creeping trait is not essential for persistance.

Key words: alfalfa, Medicago sativa, Medicago falcata, rangeland alfalfa.

1-10-5 Rhizoma Peanut, Perennial Warm-Season Forage Legume

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Rhizoma peanut is common name given species in section Rhizomatosae of the genus Arachis. 'Florigraze' rhizoma peanut (A. glabrata Benth.) has been released as a cultivar by Florida Agricultural Experiment Stations and USDA Soil Conservation Service. Florigraze is adapted to well-drained soils of Florida and warm-humid tropics and subtropics around the world. Rhizoma peanuts are propagated by rhizomes, which are best planted during winter in Florida. The slowness of coverage during early establishment is the biggest short coming of rhizoma peanuts. If established first, rhizoma peanuts will grow well in mixture with bermudagrass (Cynodon dactylon (L.) Pers.), digitgrass (Digitaria decumbens Stent.) and bahiagrass (Paspalum notatum Flugge). Average seasonal yield of Florigraze grown in mixture with a sparse stand of Pensacola bahiagrass over 5 seasons was 10.5 mt/ha. Bahiagrass without peanut yielded only 2 to 3 mt/ha annually. Pure Florigraze peanut cut at hay stage normally has protein content from 14 to 16% and in vitro organic matter digestibility (IVOMD) above 60%. Florigraze cut every two weeks had annual dry matter yield of 5 mt/ha, 22% protein, 74% IVOMD and 93% leaf in forage. Over two seasons the dry matter yield was similar at 6-, 8-, 10- and 12- week cutting intervals, 10 mt/ha. Protein, IVOMD, and leaf percentages of Florigraze rhizoma peanut progressively decreased as length of cutting interval increased from 2 to 12 weeks. Rhizoma peanuts can be used for pasture, hay, greenchop, high quality dehydrated hay and leaf meal, creep grazing, ornamental ground cover and possibly as a living mulch in which other crops and trees are planted. Weeds are the biggest pest problem with rhizoma peanuts, especially during establishment. So far, there have been no serious insect, disease or nematode problems with rhizoma peanuts in Florida.

Key words: rhizoma peanut, Arachis glabrata Benth., perennial legume, perennial peanut, hay, pasture, dry matter, cutting frequency, percent protein, percent IVOMD, leaf area index.

1-11-1

Performance and Variability of Agronomic Characters of Populations of *Stylosanthes guianensis* (Aubl.) Sw.

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Stylosanthes guianensis (Aubl.) Sw, a legume grown almost throughout the world tropics and subtropics, shows large variation in morphological and physiological characteristics, and basic informations on genetic variability are needed for future breeding programs. The objectives of this paper were to evaluate the behavior of 25 Brazilian native populations of *S. guianensis*, particularly in relation to forage valuable characteristics, and to estimate genetic and phenotypic parameters for these characteristics.

The experiment, conducted in field conditions was designed in duplicated balanced lattice 5 x 5, therefore with 12 replications. The 300 plots were constituted by four individual plants spaced 2m. The following characters were evaluated after the beginning of flowering period: number of days to flowering (DF), mean diameter (MD), basal area (BA), growth habit (GH), foliage (F), and green and dry matter yields (GMY and DMY).

Plant survival (90.2%) and dry matter yield (mean superior to 200g/plant, 211 days after sowing) evidenced the satisfactory adaptation of the species to unfavorable environmental conditions: low soil pH (4.7) and high soil aluminum content (1.8 meq/100 ml), and intense drought during 1978.

The results obtained in the analysis of variance and the genetic coefficient of variation showed the existence of genetic differences among populations for all characteristics. Based on coefficients of genotypic determination (b), GH is expected to be the character more easily alterable through selection; GMY and DMY to be the characters more difficultly alterable by selection, and the other characters to show intermediate degree of difficulty.

The correlations between means and intrapopulational variances indicate the existence of populations with high means and variances for MD, BA, GMY and DMY, indicating the possibility of making progress through selection among and within populations. For GH the correlation (r=0.530) indicates that the erect populations are less variable than prostrate populations, and that selection among populations could be more promising than selection within populations for this character.

Correlations between populations means for pairs of characters were positive and significant for the six correlations between GMY, DMY, MD and BA. All the other nine correlations were negative, but only the correlations of F with MD and BA were negative and significant. Therefore, for *S. guianensis*, it could be possible to obtain, indirectly, higher DMY through selection in favor of GM, MD and BA. Among these characters MD is the most promising for selection, because it is easier to evaluate and has the highest value of b. During the practice of selection for large MD, however, care must be taken not to select plants with lower F because the tendency of negative correlation between these characters may lead to the loss of forage quality.

Key words: *Stylosanthes guianensis* (Aubl.) Sw, phenotypic and genetic parameters.

1-11-2 White Clover: An Old Crop with a Promising Future

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White clover (Trifolium repens L.) is the most widely adapted and most important forage legume for grazing in the United States. The palatability and quality of the forage, the wide adaptation of the plants to growth in different climates and under various grazing conditions, and the role it plays in supplying nitrogen to pastures make white clover our finest pasture legume. The importance of white clover's contributions as a component of pastures has increased markedly in recent years primarily because of the rising cost of energy and growth in the world's population. The higher cost of energy has resulted in higher cost of nitrogen fertilizer and thus increased the importance of symbiotic nitrogen fixation by clovers and other legumes.

The need for a reliable, inexpensive source of protein feed is causing everyone concerned with the livestock industry to consider growing more forage legumes. There is universal acceptance that clover forage is highly digestible. This digestibility may range from 60 to 80% digestible dry matter. Some of the less obvious, yet highly economic, benefits of clover in pastures involve animal health, milk flow, calf weaning weights, and conception rate. In addition, problems with fescue-foot, grass tetany and similar maladies are minimized when grass-clover mixtures are properly utilized.

Surveys, observations, and results of research show that virus diseases are prevalent. They cause severe damage to white clover and reduce persistence. Accordingly, breeding for virus resistant white clover has top priority in the USDA white clover program. The main effort is a recurrent selection program for resistance to peanut stunt, clover yellow vein, and alfalfa mosaic viruses with priority of emphasis in the order listed. In one test for progress made in the breeding program, the incidence of infection with PSV resulting from mechanical inoculation was about 70% for Ladino compared to 30% for selected material. In a study of the nature of resistance, results from a 16-clone diallel cross indicate that susceptibility to PSV is conditioned by both specific and general combining ability. Interspecific hybridization is another viable source of virus resistance. The hybrids of Trifolium repens and T. ambiguum obtained by Dr. Williams in New Zealand provide an alternative and possibly a superior source of virus resistance. Trifolium ambiguum is highly resistant if not immune to the important viruses that infect white clover. This species hybrid offers multiple resistance from one source.

The use of adapted white clover cultivars, both now and as new cultivars are developed, should result in large economic gains to the livestock industry in the U.S. Both beef and dairy farmers would profit from reduced need for nitrogen fertilizer, an extended grazing season, increased forage production and quality, better use of land resources, a stimulation of milk flow, higher calf weaning weights, and better calving percentages.

Key words: Trifolium repens L., virus resistance, longevity, breeding recurrent selection.

1-11-3 Evaluation of Variability of Morphological and Agronomic Characters in Populations of Desmodium uncinatum (Jacq.) D. C. and Desmodium intortum (Mill.) Urb.

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This research had the following objectives: to study the performance of eight populations of D.uncinatum and ten populations of D.intortum, with relation to morphological and agronomic characters; to estimate the genetic variation between populations and between plants within populations; and to estimate genetic and phenotypic parameters to evaluate the possibility of utilization of selection.

The experiment was carried out at the National Center for Dairy Cattle Research (EMBRAPA), Minas Gerais, Brazil. It was in a randomized complete block design, with ten replications. The plots, constituted by the two species, were subdivided in eighteen sub-plots. Each sub-plot was constituted by four individual plants spaced by 1,5m. The following characters were evaluated from the beggining of the flowering period: length of main stem (LMS), number of lateral branches (NLB), number of days to flowering (NDF), dry matter production (DMY), dry matter percentage (DMP), fiber content (FC), crude protein percentage (CPP), "in vitro" digestibility (IVD), and survival after cuttings (SC).

The results obtained in the analysis of variance showed significant differences between species for the characters LMS, NLB, NDF, DMY and CPP. In addition, significant differences were observed for all characters analysed in D. uncinatum. In D. intortum there were populations which differed only with relation to LMS, NDF, DMY and DMP.

The analysis of variance of variances within subplots indicated the largest variability between plants within populations for NDF. On the other hand, the values of the coefficient of genotypic determination (b) were higher in D. uncinatum, so it would be easier to obtain changes by selection in the populations of this species than in D. intortum. Based on the b values, NDF, FC and CPP are expected to be the characters more easily alterable by selection in D. uncinatum.

Key words: Desmodium uncinatum (Jacq.) D. C., Desmodium intortum (Mill.) Urb., phenotypic and genetic parameters.

1-11-4 Value of White Sweet Lupin in Production of Protein Fodder and Feeding of Animals

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The production of grain of sweet white lupin (Lupinus albus L.) cv Bosna can be successfully achieved on acid soils (pH in H_2O 5.3-5.8) in lowland (107 m/altitude) and hilly (518 m/altitude) parts of Bosnia, but in mountainous parts (872 m/altitude) ripening is not certain. Lupin produces a higher yield in c. protein and grain than soyabean, with higher content of protein in grain but with a deficit in amino acids, especially methionine and tryptephane, which are in greater quantities in soyabean.

In the mountainous region lupin had a large yield of green fodder (31.3-32.7 t/ha) in the short growing period. The green fodder in the stage of full pod contains a low percentage of dry matter (15.6) but a high percentage of protein (26.5%), which is even higher than the green fodder of lucerne.

Silage of lupin alone has a high quality (pH 4.95 without butyric acid), and with the addition of 10 and 20% of barley the quality is improved (pH 4.7-4.8) as well as the energy value. The number of feed units in 100 kg of silage of lupin alone is 9.7; with the addition of 10% of barley it is 16.4, and with the addition of 20% of barley it is 18.0.FU. Loss of protein in silage is great (40%) and smaller of NFE (15%), with increase of c.fibers (30%). With the addition of 10 and 20% of barley, the dry matter in silage increases by 17 and 27% and NFE by 40 and 52%, while the share of dry fibers is decreased by 27 and 30% and protein by 24 and 29%.

Digestibility of nutrients in silages fed to wethers is high. The addition of barley increases digestibility of dry matter from 56 to 71%, organic matter from 50 to 70%, c. fibers from 44 to 53%, NFE from 58 to 77%, while digestibility of c. proteins remains at the same level.

Liveweight gain of lambs fed on diets in which the protein component was secured through ground grain of sweet lupin, soyabean or fishmeal was the same, and lupin gave even greater conversion of food.

Key words: white lupin, Lupinus albus L.,production, quality, digestibility, liveweight gain, sheep.

1-11-5 Mixing Ability of Genotypes of Cocksfoot with Genotypes of Lucerne and Vice Versa in Binary Mixtures

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Binary cocksfoot x lucerne mixtures, in alternate rows, of 12 varieties of cocksfoot and of 8 varieties of lucerne have been studied in order to precise the possible advantages of such mixtures and to evaluate the interactions between their components. Genotypes of cocksfoot (or lucerne) were tested with 4 genotypes of lucerne (or cocksfoot). Results from a three-year experiment are given for green matter, dry matter, and for protein content and yield in the third year.

The main result of agronomic significance is that binary cocksfoot x lucerne mixtures have yielded more dry matter and protein than the mean of monoculture with the same average amount of nitrogen fertilization.

To explain the yield of the mixture, there was neither particular interaction between the components of the mixture, nor general effects of the components (except in the first cut of the two years after the seeding year), but there was a general effect of the mixture. However, the yield of each species (direct effect) in mixture has varied significantly from one variety to another. This means there was some compensation effect.

Lucerne which was dominant, has yielded per row more dry matter in mixture than in monoculture without any change in protein content, while cocksfoot which was dominated has given less in mixture than in monoculture with an increase in protein content. Then environment of the mixture, in this trial, seems to favour nitrogen metabolism of the grass and of lucerne. Indeed protein content of the cocksfoot was greater than expected according to a negative relationship with yield, and lucerne yielded more protein per row in mixture than in monoculture.

The partner (associate) effects of lucerne were very often significant, while those of cocksfoot were not.

For each species monoculture performances explain direct effects ; nevertheless, they were not sufficient to explain their associate effect. However for some cuts in lucerne (in the spring) there was a negative relationship between associate and monoculture effects.

Then the results indicate a genetic variability of performances in mixture which cannot be explained entirely by monoculture performances. The development of varieties better suited for mixtures seems possible.

Key words: lucerne, cocksfoot, binary mixtures, competition, mixing abilities, protein yield, associate effect.

1-12-1 Selection for Specific Leaf Weight in Reed Canarygrass and Its Effects on the Plant

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Specific leaf weight (SLW, dry weight per unit leaf area) may be associated with dry matter yield in forage crops through a positive relationship with photosynthesis. Thus, SLW may serve as a selection criterion for forage yield. Two cycles of phenotypic selection for high and low SLW were conducted in reed canarygrass (Phalaris arundinacea L.) to investigate direct and correlated responses, particularly those related to yield and quality of forage.

The broad-based germplasm source NCRC1 was the base population. In each cycle, 48 to 52 plants selected from a population of approximately 1000 plants were intercrossed to form a new population. Derived populations were compared with NCRC1 as spaced plants and solid stands.

In a space-planted test, average direct responses from two cycles of selection for high and low SLW were 23 and 19%, respectively. Significant correlated responses were obtained for leaf thickness (LT), leaf width (LW), CO_2-exchange rate (CER), leaf elongation rate (LER), tillers/plant (T/P), dry weight/tiller (W/T), dry matter yield/plant (DMY), plant height (PH), seed yield/plant (SY), and 100-seed weight (SW). The correlated changes were in the same direction as the changes in SLW for all traits except T/P. The changes in CER from selection for high SLW usually were small and not significant. Compared with the low SLW cycle-2 population, the high SLW cycle-2 population averaged 52% higher in SLW, 38% greater in LT, 13% greater in LW, 12% higher in CER, 24% higher in LER, 38% lower in T/P, 83% higher in W/T, 39% higher in DMY, 15% greater in PH, 55% higher in SY, and 22% higher in SW. The populations were similar in date of anthesis.

In solid stands, the high and low SLW cycle-1 populations did not differ significantly in dry matter yield over three years when harvested either three or five times per year. Under both harvest frequencies, the high SLW population yielded slightly more than the low SLW population.

No consistent differences were found between high and low SLW populations in forage quality of nonflowering regrowth. The parameters determined were in vitro dry matter digestibility, neutral and acid detergent fiber, hemicellulose, cellulose, permanganate lignin, silica, and insoluble ash.

Results from the spaced plants suggested that SLW reflected some basic aspect of growth and development, possibly size of shoot apices and associated leaf primordia, which was an important factor in forage and seed yield under low competition.

Key words: reed canarygrass, Phalaris arundinacea L., recurrent selection, specific leaf weight, correlated responses.

1-12-2 Evaluation of Italian Populations of *Dactylis glomerata* Grown at Different Locations

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The main aim of this study has been to evaluate agronomical performance and variability between and within populations of Italian ecotypes of *Dactylis glomerata*. Eighty-one ecotypes of *Tetraploid Dactylis glomerata* were collected from throughout the Italian peninsula and grown at 3 different locations, Northern, Central and Southern part of Italy. Each population, represented by 60 spaced plants, was evaluated for heading time, plant height and green yield.

The earliest types were those from Southern Italy and the latest from Northern. Variability among ecotypes was greater in materials from Central Italy and lower in those from the South. The variability within populations was higher in the Northern materials and lower in the Southern. The highest values of variability were exhibited in the Central locations. Plants from North Italy were taller and those from Central Italy shorter. The highest values were shown in the Northern locations, where the maximum variability was also detected. Absolute values and variability observed in Central Italy were not different from those observed in the South. The same trend was observed in variabilities within populations. Green yield was higher in the Northern material and lower in the Central. In this location the lowest variability between populations was observed. Variability within populations had the same trend in different materials and different locations.

In addition to the selection of interesting types for further breeding programs, the following general conclusions can be drawn. Heading time is the best character for detecting variability between and within populations. It is also the character that shows the greatest difference between locations. The other two characters appear to be controlled to some extent by heading time. The Central location seems to allow the maximum expression of variability while plants at the other two locations are affected by cold conditions in the North and drought in the South.

Key words: *Dactylis glomerata*, heading time, plant height, yield.

1-12-3 Analysis of Adaptability in a Tall Fescue Strain Testing Program Using Data Base Technique

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The data base (DB) technique was applied in the analysis of adaptability of newly bred tall fescue (*Festuca arundinacea* Schreb.) strains in order to utilize information accumulated in the regional testing data very efficiently and easily. A breeding project at the Hokkaido National Agricultural Experiment Station has brought up 6 promising Hokkai strains, and a test over 18 locations throughout Japan for 3 years revealed outstanding performance of Hokkai Nos. 1 and 2 (registered as Hokuryo and Yamanami by the Ministry of Agriculture, Forestry and Fisheries later) over standard variety Kentucky 31. Part of data obtained in this strain testing program was computerized as DB and was subjected to the use of DB management system EXIR and related computer programs to find out efficient ways to utilize information in plant breeding.

EXIR was developed at the University of Colorado for the use of genetic resource management, but later addition of report generator and several program packages for statistical analyses (altogether, named as EXIS) increased its potentiality for the use in evaluation or analyses of materials or strains in the course of breeding project. Thirty-six descriptors defined include 1) descriptive features like testing location, latitude, date of clipping, strain name, 2) agronomic traits like dry matter yield plant height, 3) climatic conditions like temperature, precipitation, hours of sunshine, day length and so on during growth of the crop. As the result of queries by appropriate combination of logical operators like *and*, *or* or *not*, data for analysis were retrieved, stored into disk file and passed to the subsequent programs like RPG, MINITAB, NTSYS or others.

Regression analysis on mean performance of all strains in the south-central Hokkaido indicated very high yielding ability of Hokuryo under good environmental conditions and general adaptability of Yamanami. Regression analysis through all testing environments revealed highly significant yield response of all strains to number of growing days, accumulated temperature and day length. In addition to this, relative proportion of regression sum of squares corresponding to the ordered successive inclusion of these three variables made clear the difference between Hokuryo and Yamanami or Kentucky 31 in their mode of response to climatic conditions. Common or specific pattern of dry matter production of these strains through testing environments was also observed in the result of principal component analysis. Further analyses of the data figured out the difference among strains and provided useful information for the future breeding of this crop.

This study aims at surveying how and to what extent a computer system like EXIS could help the progress of plant breeding. Ease of data retrieval corresponding to any complex queries representing breeder's intention and free choice from methods of statistical analyses are great merits in the DB utilization not only for the analysis of adaptability but also for many other stages of plant breeding.

Key words: tall fescue, Festuca arundinacea Schreb., adaptability, data base, computer, multivariate statistical analysis.

1-12-4 Effective Selection for Tolerance to Grass-killing Herbicides in Agricultural Grass Species

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The aim of grassland reseeding is to establish a high quality sward of improved herbage cultivars. To obtain the maximum value from the improved sward, weed invasion should be prevented. Herbicides are the main tool available. There are many herbicides for selectively controlling dicotyledonous, but not graminaceous, weeds. The control of graminaceous weeds would be possible in swards of grass cultivars selected for tolerance to grass-killing herbicides.

Two cycles of recurrent selection for glyphosate tolerance in perennial ryegrass (Lolium perenne L.) were carried out by spraying large seedling populations with critical dosages in the glasshouse, and polycrossing the survivors. It was found that two populations selected in this way were about 50% and 67% more tolerant than two control cultivars.

To combine the paraquat tolerance of the perennial ryegrass cultivar Causeway with the agronomic characters of cv Aberystwyth S 23, crosses were made between the two and selection for tolerance was practised on seedlings of the F_2 and F_3 generations. The F_3 and especially the F_4 were found to be even more tolerant than Causeway.

These results illustrate the feasibility of breeding for herbicide tolerance in grasses. Herbicide tolerant cultivars would facilitate the establishment and maintenance of weed-free pastures and seed crops, the maintenance of varietal purity, distinction of the cultivars from others of the species, and experimentation on pure single-species grass swards.

Key words: perennial ryegrass, Lolium perenne L., herbicide, glyphosate, paraquat, selection, tolerance.

1-12-5 Comparison of Italian Ryegrass and Meadow Fescue with F_2, F_3, and F_4 Hybrids of Both Grass Species

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In forage grass breeding there is an increasing interest in hybrids of Italian ryegrass (Lolium multiflorum Lam.) and meadow fescue (Festuca pratensis Huds.). The objective of this study was to investigate some agronomic properties of such Festulolium hybrids with special reference to the question whether these hybrids change from one generation to the next.

In a pot experiment with four levels of nitrogen fertilization Italian ryegrass and meadow fescue as well as F2, F3, and F4 hybrids of the two grass species were examined for two years. In each year four cuts were taken. All the F2, F3, and F4 hybrids were descendants of a single F1 plant. Therefore, some inbreeding effects must be taken in account in spite of open pollination of the hybrids. The fertility of the hybrids increased from one generation to the next.

In the first year, after sowing the grasses in spring, meadow fescue produced substantial lower yields than Italian ryegrass at the higher nitrogen doses and died off almost completely at the highest nitrogen level. The yields of the hybrids in this year exceeded those of meadow fescue and, at lower nitrogen supply, even those of Italian ryegrass. Very high nitrogen doses were tolerated by the hybrids much better than by meadow fescue, but not quite as well as by ryegrass.

In the second year, after wintering, all the grasses formed culms, with Italian ryegrass showing the most abundant culm development. The hybrids outyielded meadow fescue and ryegrass in the second year nearly without exception. In general, the yields of the hybrids were distributed more evenly among the various cuts than those of Italian ryegrass. On average of both years the hybrids mostly gave noticeably higher yields than both the parent species.

Within the different nitrogen levels the crude protein content was the lower and the content of water-soluble carbohydrates usually was the higher the more dry matter was produced by the respective grass. The crude fibre content of the hybrids often proved to be somewhat higher than that of Italian ryegrass, but not higher than that of meadow fescue.

In regard to yield, quality, and response to nitrogen no well-defined changes could be stated with the succession of hybrid generations. Especially there was no evidence for any rapid approach of the hybrids to one of the two parent species. This may encourage plant breeders to deal with such hybrids.

Key words: Festulolium, Italian ryegrass, meadow fescue, yield, quality, nitrogen.

1-13-1 Breeding *Centrosema pubescens* Better Adapted to the Acid Infertile Soils of South America

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Continued use of *Centrosema pubescens* Benth. in tropical South America depends upon development of lines with increased tolerance to high acidity and aluminum (Al) levels. The present study aimed to classify levels of acid tolerance among numerous *Centrosema* introductions and among crosses of the more promising introductions.

Initially, glasshouse and field evaluations in Carimagua oxisol (pH 4.5, 90% Al saturation) were used. Introductions of *C. schottii* and *C. pascuorum* died, while most *C. virginianum* and *C. acutifolium* and a few of *C. pubescens* had low acid tolerance. Most *C. pubescens* introductions had medium acid tolerance, whereas some *C. macrocarpum* and *C. schiedeanum* were highly acid tolerant. The degree of acid tolerance in introductions appeared to be directly related to their Al uptake.

Several promising *C. pubescens* introductions, and one each of *C. macrocarpum* and *C. schiedeanum*, were selected for crosses aimed at increasing the acid tolerance of *C. pubescens*. Most crosses obtained were between *C. pubescens* introductions, there being none with *C. schiedeanum* and only one with *C. macrocarpum*, viz. 5052 x 5062.

Rapid glasshouse screening of F_2 populations for acid tolerance was achieved, first in sand culture and then in Carimagua soil. Increased efficiency in sand culture screening was obtained by reducing Al to 4.5 ppm and continual use of 10 ppm nitrogen (N). None of the best *C. pubescens* introductions, nor their F_2s had more than medium acid tolerance.

The fertile *C. pubescens* x *C. macrocarpum* has provided the basis for the selection of highly acid tolerant lines, combining the best features of both parents. The high acid tolerance of *C. macrocarpum* was inherited in about 20% of F_2 plants.

Key words: *Centrosema* spp., acid soils, adaptation, acid tolerance, aluminum, selection.

1-13-2 Evaluation of Within-Half-Sib Family Selection from Leo Birdsfoot Trefoil

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This research was undertaken to evaluate the effectiveness of within-half-sib family recurrent selection for seedling vigour, seed yield and forage yield in birdsfoot trefoil (Lotus corniculatus L.) cultivar 'Leo'. The effectiveness of selection was measured by comparing progeny performance, genetic variances and heritabilities in selected and unselected populations. In addition, experimental synthetics (Syn 2 generation) from the selected population were compared to the check cultivar Leo for forage yield and seed yield in several trials.

Seedling vigour and seed yield in 1979 and forage yield in 1980 of polycross progeny in the selected population were significantly higher than similar progeny in the unselected population. Forage yield in 1979 of polycross progeny was similar in the selected and unselected populations. Seedling vigour of selfed progeny in the selected progeny performed at a level similar to the polycross progeny of the unselected population. Although self progeny performances in the selected and unselected populations were similar in magnitude for seed yield and forage yield the relative decline was greater in the selected population.

Estimates of genetic variance indicated significant and similar levels of additive variation for forage yield in row plots and non-significant dominance variation in both populations. Heritabilities were similar in the populations tested.

Both the third and fourth cycle populations advanced to the Syn 2 generation were significantly higher yielding in the year of seeding (a measure of seedling vigour), similar in the second year and significantly higher in the third year when compared to Leo. Seed yield was below Leo for the third cycle population and above Leo for the fourth cycle population. Selections from the fourth cycle for seedling vigour and seed yield were made based on progeny testing. The seedling vigour selection had significantly higher forage yield in the year of establishment compared to Leo while the seed yield selections had about 40% higher seed yield than Leo.

Failure to observe significant levels of dominance variation and greater inbreeding depression in the selected population suggest that additional populations of diverse genotypic background would be necessary to obtain optimum performance when elite genotypes are used as parents for new cultivars.

Performance of experimental synthetics from the selected population has been significantly above the variety Leo for forage yield in the establishment year and much better for seed yield. The improved performance and maintenance of genetic variability of these populations is evidence of the success of this selection method in birdsfoot trefoil.

Key words: birdsfoot trefoil, Lotus corniculatus L., recurrent, selection, progeny testing, seedling vigour, forage yield, seed yield, forage legumes.

1-13-3 Evolution of Selection Techniques in Breeding for Bloat-safe Alfalfa

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This report summarizes the Canadian breeding program to develop a bloat-safe alfalfa (Medicago sativa L.). This program has experienced an evolution of selection methods in attempting to identify bloat-safe alfalfa genotypes. In chronological order the methods involved selection for: fraction I (18S) protein, soluble proteins, foam volume, tannins (flavolans), saponins, initial rate of digestion (IRD), sonication, purified enzymes, gas production and leaching.

Although soluble herbage proteins are correlated with the occurrence of pasture bloat, we have experienced slow progress in a selection program to reduce soluble protein concentration in alfalfa. We have found that foam volume is not correlated with either soluble protein or bloat incidence. After an extensive search in 33 annual and 25 perennial species of Medicago, no tannins have been found. Similarly, a mutation approach to induce flavolan production in alfalfa has failed to reveal tannin (bloat-safe) phenotypes. Seedcoats of alfalfa were found to contain tannins. The saponin theory of bloat has been proven to be invalid.

A comparison of bloat-safe and bloat-causing forage legumes revealed slower initial rates of digestion and lower concentrations of intracellular leaf constituents in rumen fluid when bloat-safe legumes are ingested. Selection is underway to develop contrasting alfalfa synthetics, one with low initial rate of digestion (bloat-safe synthetic) and another with a high initial rate of digestion. Preliminary data indicate genetic progress for change in initial rate of digestion with no change in overall digestibility as measured by in vitro dry matter digestibility.

Several new complementary techniques are under development and evaluation to select bloat-safe alfalfa plants. They are all devised to measure basic parameters involved in the etiology of bloat (i.e., cell wall strength, enzymatic breakdown of cells, microbial degradation, gas production, leaching).

Key words: pasture bloat, alflafa, Medicago sativa L., cattle, selection techniques, breeding.

1-13-4 Development of Gama Medic (*Medicago rugosa* Desr.) as an Annual Leguminous Species for Dryland Farming in Southern Australia

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Annual medics, (*Medicago* spp.) are the basic legume for nitrogen fixation in the alkaline soils of southern Australia. Individual species are not all well adapted to all soil types, one difficult soil being the highly alkaline clay loams where annual rainfall is less than 500 mm.

The adaptation of gama medic (*M. rugosa*) to these soils was first appreciated after assessment of many genotypes of several other species. The first developed cultivar, Paragosa, was well adapted to the clay-loam soil type but proved to be susceptible to germination after summer thunderstorms. The resultant seedlings died in the following drought. Many accessions were then grown in an attempt to select a genotype capable of maintaining seedcoat impermeability during the summer but having sufficient permeable seed by mid-April to allow dense regeneration. Other essential criteria included good winter herbage production, earliness of flowering, and high seed yield. These genotypes were grown to maturity in the field nursery and sampled at regular intervals over the summer/autumn period to measure changes in seedcoat permeability. Subsequent sward sowings in different environments allowed measurement of the other criteria.

Data from the screening of 1,364 genotypes of 13 species revealed the variability in gama medic compared with other species. Although all gama medic genotypes from the eastern Mediterranean region maintained a high level of seedcoat impermeability, genotypes from Greece, Italy and Portugal displayed a range of changes between maturity and mid April. Evaluation for this and other criteria resulted in the development of the cultivar, Paraponto.

The principle of nitrogen fixation by legumes in the ley farming systems practised in the Mediterranean-type climatic zone of southern Australia is accepted and used by cereal producers and graziers, its significance being reflected in increased frequency of cropping as well as increased yields and greater stock carrying capacity.

Species other than previously recognised commercial species have application to specific environments and a more intensive search for, and evaluation of genotypes of the relatively rare species, gama medic, as well as other potentially useful species could result in more productive and better adapted cultivars in the future.

Key words: gama medic, *Medicago rugosa* Desr., alkaline clay loams, seedcoat permeability, herbage and seed production, flowering time.

1-13-5 Productivity of Forage Legumes on Rice Paddy Walls in Northeast Thailand

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Rice stubble left standing in paddy fields after rice harvest is the major source of forage for livestock in the dry season in Northeast Thailand. Although the quantity of this stubble is generally not limiting its quality as a forage is very low and substantial liveweight losses in livestock usually occur by the end of the dry season.

A trial was conducted to evaluate a range of forage legumes which could be grown on rice paddy walls to supplement rice stubble as a dry season feed. Seven legumes were planted at two sites in villages close to Khon Kaen in Northeast Thailand. The dry matter yield and nitrogen content of each species was measured in two consecutive years just prior to the rice harvest. In both years, Shrubby stylo (Stylosanthes scabra cv. Seca), Verano stylo, (S. hamata cv. Verano) and Viscosa stylo (S. viscosa) were the most productive species with mean dry matter yields of 4,800, 3,320 and 2,340 kg ha^{-1} $year^{-1}$ respectively. A simple cultivation treatment improved legume establishment and growth particularly in the first year. Nitrogen (N) contents ranged from 0.8% N in Shrubby stylo to 3% N in Leucaena (Leucaena leucocephala). Although the yield of Shrubby stylo was the highest, a large proportion of its yield was inedible thick stem material so that its effective yield was considerably lower. Verano stylo was considered the most suitable legume for this practice. It established and regenerated easily, persisted well, was readily eaten by livestock and it substantially increased the quality and quantity of fodder available to livestock from the paddy walls.

Key words : rice stubble, Stylosanthes spp. verano stylo, shrubby stylo, paddy walls, Northeast Thailand.

1-14-1

Alfalfa Breeding for Forage Yield and Low Saponin Content

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The breeding program is aimed to build alfalfa (Medicago sativa L.) varieties having a good performance (vigor and persistence), a high protein level and a low saponin content. The breeding method utilizes a selfing phase combined with selection in competitive conditions. High protein content is researched through improvement of resistance to frequent cutting. The leaf saponin content is analyzed by bioassay which utilizes the fungus Trichoderma viride.

Parental populations (cv. Leonicena and cv. Cantoni), S_0, S_1, and S_2 families were evaluated under competitive and frequent cutting conditions. In both populations some S_2 families yielded more than their respective S_1. The range of variation increased with the level of selfing. Mortality also increased with the level of selfing. It is interesting to notice that some S_2 families showed lower minimal values of mortality than the S_0 families. These persistent S_2 families were the earliest in flowering and the most homogeneous for this character.

On the basis of these results, it seems possible to say that the inbreeding depression is a parameter depending by a large amount on the experimental conditions: density of growing, cutting frequence, arrangement of progenies on the field.

Concerning the saponin content of the leaves, a positive correlation exists between S_1 families and S_0 mother plants:

$r = 0.817^{++}$ for Leonicena and $r = 0.827^{++}$ for Cantoni.

Key words: alfalfa, autotetraploid, competition, inbreeding, Medicago sativa L., selection, saponin.

1-14-2

Forage Quality of Barley Straw as Influenced by Genotype

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Cereal straw is the largest, basically untapped carbohydrate source for ruminant animal feeds. Differences in feeding value of straw among cereal species are well documented, but little information is available on genotypic differences in the feeding value of barleys (Hordeum vulgare L.) commonly grown in the Northern Great Plains of the United States. Our objective was to determine if barley genotypes differed in straw forage quality and if straw quality parameters were associated with agronomic characters.

Straw from 37 and 31 barley genotypes was sampled in 1977 and 1978, respectively. Straw from 10 barley genotypes grown at four locations was sampled in 1979. Standard lab procedures were used to determine the quality parameters measured. Correlations among straw quality parameters and agronomic characters were determined in 1977 and 1978.

Barley straw tested in 1977 and 1978 averaged 5.6% crude protein (CP), 42.0% in vitro dry matter disappearance (IVDMD), 50.7% acid detergent fiber (ADF), 71.8% neutral detergent fiber (NDF), 6.6% acid detergent lignin (ADL), 21.1% hemicellulose, 11.4% ash, 0.13% phosphorus, 0.58% calcium, and 0.20% magnesium. The average feeding value was different among environments with higher quality straw produced in low grain yield environments.

Significant differences among barley genotypes were found for most straw quality parameters measured. Six-rowed barley straw generally was lower in forage quality than 2-rowed barley straw. Straw from feed and malting barleys were similar in forage quality. Straw from 'Karl' barley, a low grain protein cultivar, was higher in CP and digestibility and lower in ADF and NDF than most genotypes. Significant genotype x environment interactions were detected for most straw quality parameters except CP. Heading date and plant height correlations with straw quality components varied among years. Grain, straw, and protein yields; lodging; and grain protein percentage were not consistently correlated with a straw quality component.

We have demonstrated potential useful differences in straw forage quality among barley genotypes. The data suggest that genotypes high in straw quality can be selected without loss of desirable agronomic characters.

Key words: Hordeum vulgare L., straw, forage quality, barley genotypes, straw digestibility.

1-14-3 Some Responses of Meadow Voles to Alkaloids in Reed Canarygrass

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The purpose of this report is to integrate three studies with the following objectives: (a) to evaluate meadow voles (Microtus pennsylvanicus as a bioassay of alkaloids that occur in reed canarygrass (Phalaris arundinacea L.) and (b) to determine the relative toxicity to voles of several alkaloids that occur in reed canarygrass. Nine alkaloids have been identified in this grass, and a knowledge of their importance would enhance programs to improve the usefulness of this grass as a forage species.

A single-meal intake test was used to evaluate the palatability of some alkaloids as they occurred in fresh grass and in semi-synthetic diets. Purified gramine and hordenine sulfate were fed in semi-synthetic diets for 21 days to determine their effects on intake, body-weight gains, and animal health.

Palatability of 14 clones of reed canarygrass and semi-synthetic diets with various concentrations of gramine, hordenine sulfate, and tryptamine-HCl was negatively correlated with their total alkaloid level. Semi-synthetic diets that contained 0.5% 5-MeO-N, N-dimethyltryptamine; N, N-dimethyltryptamine; 5-methoxytryptamine-HCl, or N-monomethyltryptamine were unpalatable. The effects of gramine, hordenine, and tryptamine-HCl on palatability were additive when they were fed together in semi-synthetic diets.

In the 21-day feeding trials, approximately one-third of the voles died on diets that contained 0.25 or 0.5% gramine, whereas there were no deaths on any of the diets that contained hordenine. Voles that survived on gramine diets had kidney lesions, glycosuria, higher intakes, and lower weight gains than control animals. Voles fed 0.25 and 0.5% gramine had increased circulating reticulocyte levels, and those fed 0.125% had higher alkaline phosphatase activity than the control voles.

Hordenine did not affect intake, weight gain, or mortality rate. Voles fed hordenine developed kidney lesions, and glucose was detected in the urine of 62% of these animals.

Gramine was more toxic than hordenine on a molar equivalent basis.

We concluded that voles provided a good bioassay for estimating the palatability of reed canarygrass lines which differ in alkaloid types or concentrations. In the 21-day feeding trials, responses of voles with regards to diet intake were not comparable to results reported by Marten et al. (Agron. J. 68:909, 1976) with large ruminant animals. Gramine was more toxic than hordenine to voles.

Key words: reed canarygrass, Phalaris arundinacea L., meadow voles, Microtus pennsylvanicus, alkaloids, toxicity.

1-14-4 Neutral Detergent Fiber and Protein Levels in Diploid vs. Tetraploid Ryegrass Forage

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Nutritive value of 18 ryegrass (Lolium multiflorum Lam.) cultivars was studied at Overton, Texas during a 3-year period to determine the variation in protein content and neutral detergent fiber (NDF) of 9 diploid versus 9 tetraploid ryegrass cultivars as influenced by season. Comparisons were also made within diploid and tetraploid cultivars.

Samples to be analyzed were collected from forage variety tests for the growing seasons of 1976-79. Ryegrass cultivars were drilled into conventionally tilled seedbeds prior to mid-September and fertilized at a rate of 67 kg/ha for N, P_2O_5, and K_2O. Additional N was applied in split applications in November and February for a total seasonal rate of 235 kg/ha. The forage was clipped at a uniform height of 5 cm with a flail-type harvester. Forage samples were oven dried and ground to pass a 40-mesh screen. Plots were harvested four times during each of the first 2-years and five times on the third year. In 1977-78 and 1978-79, NDF and protein were run on samples from 2 replications. All forage samples were analyzed for protein via the micro-Kjeldahl technique. Percent NDF was obtained via Van Soest extraction procedures.

A seasonal decline in both neutral detergent solubles (NDS) content and protein percent was observed. Differences in NDF were observed among cultivars and were most apparent during April and May. The differences likely were related to maturity levels of individual cultivars since earlier maturing cultivars tended to have higher NDF levels. Since tetraploids in this study were generally about 2-weeks later in maturation, as a group, they were significantly lower in percent NDF components in April and May. Protein levels decreased during the growing season from about 25% in December to about 13% in late May. No significant differences in protein content were observed between cultivars or between diploid versus tetraploids.

Key words: Lolium multiflorum Lam., forage quality, total structural carbohydrates.

1-14-5 Use of Chemical Components in Digestibility Predictions of Eight Tropical Grass Genotypes with Increasing Maturity at Two N Levels

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A rapid and reliable chemical method to determine forage quality would help a researcher in parts of the tropics, where facilities for *in vivo* measurements and/or maintenance of fistulated animals are often inadequate. Predictive equations derived from relationships between chemical components and digestibility would therefore be meaningful even if they are of limited value. Such relationships between crude protein (CP), crude fiber (CF), acid detergent fiber (ADF), silica (SiO_2) and lignin (L) with *in vitro* digestibility (IVDMD) were attempted with 8 tropical bunch grass genotypes, namely, two interspecific hybrids of *Pennisetum americanum* x *P. purpureum*, two improved strains of *P. purpureum*, two of *Panicum maximum* and one genotype each of *Andropogon gayanus* and *Brachiaria brizantha*.

The grasses were planted by stem cuttings and maintained at two nitrogen (N) levels (0 and 225 kg N/ha). Herbage was cut at 3, 6, 9 and 12 week intervals during two growing seasons for analysis of chemical composition and digestibility.

Considerable inter- and intraspecific variations in chemical components and digestibility as well as in their rate of change with maturity were observed. Such differences were reflected in the unsatisfactory relationships between chemical components and digestibility when data for all genotypes were pooled together. The r^2 values obtained for CP, CF, ADF, SiO_2, and L were 62, 55, 2, 24 and 46 respectively.

The correlation values obtained between various chemical components and digestibility were high when computed on an individual species basis. Data indicated their usefulness as predictors of digestibility within related genotypes of the same species. CP is easily and routinely determined in the laboratory and it gave the highest correlation with digestibility with r^2 values for the 8 genotypes ranging between 79 and 94. It is therefore suggested that CP be used as a reliable predictor of digestibility in tropical forage grasses.

Key words: tropical bunch grasses, chemical components, digestibility, digestibility predictions.

1-15-1 Leucaena Outlook for Cattle Production in Cuba

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During recent years interest in Leucaena leucocephala for cattle feeding in Cuba has grown.

Agronomic, nutritive values and animal utilization studies have been carried out in ferralitic soils in areas where rainfall oscillated between 1300 and 1600 mm/year, with or without sprinkler irrigation.

In introduction fields the Cuban cultivar (cv) Varadero yielded between 7.8 and 8.8 t/ha/year of dry matter (DM), producing more when cut at 20 cm height (8.8 t/ha) than at 10 cm (7.7 t/ha). In cutting experiments with the same cv it was established that in sowings carried out early in the wet season, harvests at 4½ months showed a higher yield (8.1 t/ha) than those at 3 and 6 months. Cutting at 50 cm height was better than that at 20 cm (8.2 vs 6.0 t/ha), while cutting at longer intervals produced more than at the shorter ones (10.0, 7.9 and 3.4 t/ha at 10.8 and 4 weeks, respectively). Chemical composition showed little differences between harvesting intervals or cutting heights, and such differences were highest between leaves and stem. Crude protein (CP) content varied between 24 - 32% and 19 - 29% for the dry and wet seasons, respectively. In another experiment under simulated rotational grazing, the introduced cv Peru doubled the annual yield of edible DM (15.9 t/ha) compared to Varadero (7.0 t/ha and Glycine wightii cv Tinaroo (6.0 t/ha). CP percentages in the dry and wet seasons were 30.1 and 34.4%; 26.8 and 33.3% and 19 3 and 21.4% for the three cvs, respectively. In vivo bag digestibility for Cunningham (84.5%) and Peru (84.4%) cultivars was higher than in Varadero (81.0%). In a short-term trial (23 days) one kg of DM/day of Leucaena substituted for half of the concentrates supplied to cows grazing star grass (Cynodon nlemfuensis). Milk production was 15.2 liters/cow/day when only concentrates were consumed (4 kg/day) and 15.1 liters/day when 2 kg of concentrates plus 1 kg of Leucaena were fed.

The advantages and inconveniences for its exploitation are discussed and further studies with this legume are necessary.

Key words: Leucaena leucocephala, legumes.

1-15-2

Collections of Western Wheatgrass and Blue Grama and Associated Nematode Genera in the Western Dakotas

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Western wheatgrass (Agropyron smithii Rydb.) and blue grama (Bouteloua gracilis [Willd. ex H.B.K.] Lag. ex Griffiths) are widely distributed throughout the United States. They are two of the predominant native grasses in rangelands in the Northern Great Plains. Because suitable cultivars are not always available for reseeding disturbed areas, we collected plants of the two species and evaluated phenotypic variability to determine potential for breeding improvement. We also sampled the nematode population associated with the collections.

Sampling sites were systematically chosen by establishing a grid pattern 19.3 km apart in the western halves of North Dakota and South Dakota. Five collections, including a portion of the root system, were made of each species at each of about 1,040 sites in 1977 by SCS field technicians. Individual plants were extracted from samples and transplanted to the field for agronomic evaluations. Nematodes were extracted from the soil fraction of the collection samples.

Data collected on individual plants were averaged over all plants collected at one site (entries). Relative maturity of western wheatgrass entry means ranged from 178.2 to 195.0 Julian days and from Julian date 169 to 204 for individual plants. Average fertility for entry means was 35.6% and mean seed yield from 5 heads was 0.59 g. Awn length ranged from none to 5 mm. Fewer characteristics were measured on blue grama than on western wheatgrass. The maturity range for blue grama was 13.5 days for entry means and 15 days for individual plants.

Plant parasitic nematodes were found in 59% of the 3,099 soil samples analyzed. The most prevalent genera found were Helicotylenchus, Paratylenchus, Xiphinema, and Tylenchorhynchus. Plant parasitic nematode genera associated with blue grama (1,606 samples) and western wheatgrass (1,493 samples) were similar. Paratylenchus was the most prevalent genus in North Dakota and Helicotylenchus was the most prevalent in South Dakota.

We concluded that sufficient phenotypic variability existed in western wheatgrass to warrant initiating a breeding program. Blue grama varied in maturity but other characteristics were not identified, so initiation of a breeding program will be delayed until further investigation of variability is conducted. Plant parasitic nematodes were commonly found in range sites indicating the need for determining their effect on range productivity and persistence of vegetation.

Key words: selection, grass breeding, vegetative collection, germplasm evaluation, western wheatgrass, Agropyron smithii, blue grama, Bouteloua gracilis, nematodes.

1-15-3 Test Adaptation and Evaluation of Forage Plants in Major Ecological Regions in Ethiopia and Kenya

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The Kenyan and Ethiopian natural grazing lands support more than 20% of the cattle population of the African continent. Much of these countries' natural pastures are severely overgrazed. The livestock off-take is low mainly due to the unfavourable grazing conditions which prevail more than half of the year.

The objectives of the test adaptation trials is to provide and select new introduced or indigenous forage and fodder adapted species or ecotypes with genetic potential for high production of digestible dry matter for direct pasture and range improvement and for future use in breeding programmes.

In Kenya and Ethiopia over 4,000 and 3,000 entries of indigenous and introduced ecotypes were screened in six ecological regions and each was evaluated for 26 vegetative characters between 1971-1980.

In the cool wet highlands situated between 2300-3000 m with rainfall ranging between 1000-1250 mm, the promising species were oats (Avena sativa), woollypod vetch (Vicia dasycarpa), perennial ryegrass (Lolium perenne), Kentucky bluegrass (Poa pratensis), cocksfoot (Dactylis glomerata) and tall canarygrass (Phalaris tuberosa).

The promising species in the temperate wet highlands ranging between 1850-2000 m with rainfall between 1000-1290 mm were woollypod vetch, oats, rhodesgrass (Chloris gayana), setaria (Setaria anceps), tall guineagrass (Panicum maximum), napiergrass (Pennisetum purpureum), fine stylo (Stylosanthes guianensis).

In the warm wet medium altitude covering altitude 1500-1700 m and having an annual rainfall between 1250-2000 mm, the promising species in the wetter areas were napiergrass, rhodesgrass, tall guineagrass and tall setaria. In the drier areas, the productive and adapted species were African foxtail (Cenchrus ciliaris), coloured guineagrass (Panicum coloratum), Masai lovegrass (Eragrostis superba), glycine (Glycine wightii), centro (Centrosema pubescens), siratro (Macroptilium atropurpureum), silverleaf desmodium (Desmodium uncinatum) and fine stylo.

The hot dry lowland region occurs in Kenya between 150-900 m with average annual rainfall between 450-850 mm. The promising species are Masai lovegrass, African foxtail, scabra stylo (S. scabra), several saltbush species (Atriplex spp.), mesquite (Prosopis juliflora) and koa haole (Leucaena leucocephala).

The hot humid coastal region in Kenya has an average annual rainfall of 1015-1270 mm. The adapted and productive species are similar to a great extent to those of the warm and wet medium altitudes.

The potential forage production of a great part of the different ecological regions could be substantially increased by sowing highly productive forage and fodder species and by the proper management of these lands.

Key words: Ethiopia, Kenya, forage crops, adaptation, evaluation East Africa.

1-15-4

Atriplex, a Prospective Forage Crop in Saudi Arabia

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Atriplex species are adapted to different agroclimatic regions, including arid and saline regions. Some species are perennial evergreen shrubs. Their palatability for livestock attracted the attention of forage crop investigators all over the world.

The effects of salinity on seed germination, growth of seedlings and internal structure of the stem were studied for about two years, dealing with seven species of Atriplex. Protein content of the seedlings was also investigated. Moreover, both the stems and the leaves of mature plants were chemically analysed.

Seed germination decreased significantly as the salinity level increased. The highest concentration (5000 ppm or more) inhibited completely seed germination. The effect of salinity on the growth of seedlings followed the same trend as in seed germination.

In the seedlings, chemical analysis revealed a high percentage of crude protein, which decreased with the increase of salinity levels. The yield and the crude protein content of Atriplex plants were higher than those of other pasture grasses and legumes grown under the same conditions.

Anatomical studies showed that the size of the vascular cylinder decreased with increase of salinity levels. Lignified tissues (xylem and xylary fibers) were reduced as salinity increased. However, there was an increase in the parenchymatous tissues, which showed the tendency of acquirement of halosucculent properties.

Key words: Atriplex, Saudi Arabia, salinity, protein, internal structure.

1-15-5 Breeding of Guinea Grass (*Panicum maximum* Jacq.) in Cuba

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A program of breeding guinea grass in Cuba began in 1973 with the whole national territory collection and the introduction of African cultivars fundamentally. At the present time, our stock contains 800 accessions from which 90% are natives and the others are foreign. This collection was characterized for both qualitative and quantitative aspects, which permitted to group the Cuban accessions in different morphological ecotypes.

Subsequently isoenzymatic markers were employed for classification, together with qualitative morphological characteristics, using in the last case multivariate analysis.

In the first stage of the selection process in furrows (first selection) a wide inter-accessions variability was determined in dry matter yield in dry and wet seasons, 8-222 g DM/bunch and 22-300 g DM/bunch, respectively. Crude protein content ranged from 5% to 17% and from 9% to 21% in the wet and dry seasons, respectively. Leafiness varied from 50 to 100. There was variation in the DM yield stability; in this case, only 4.5% of the accessions maintained yield stability and 94.5% of accessions were unstable, with a variation range from 20 to 45% with respect to the yield produced in the wet season or in the first year.

Multiple correlations were obtained among height, diameter and yield: $y=1246 + 1586\ x_1 + 2348\ x_2$ with $r=0.86$ (P 0.001), which simplifies the first selection stage taking only vegetative height and bunch diameter in selecting all plants with height and diameter higher than the respective population means.

Variability was observed in the number of flowering periods in the year, with three principal periods of flowering: I, March-May; II, June-July; and III, September-November, in which the major number of panicles are produced and the majority of the accessions flowers.

The number of panicles/bunch/day ranged from 0.02 to 4.7, with a tendency to decrease in the second year from 0.02 to 3.5 panicle/bunch/day.

The optimum harvest time of seed changed according to the length of the flowering period, but generally 15 days after the beginning of the "flat" leaf stage the higher amount of full seed can be obtained, although the greater quantity of fertile seed was obtained at 20 days.

There were evaluated in nursery 750 accessions, 126 of them passing to comparative trials. Twelve accessions were outstanding and are being evaluated in different husbandry areas of the country. In recent years a crossing program has been begun, from which 120 hybrids have been obtained, some of them presenting good prospects of selection.

Key words: guinea grass, *Panicum maximum* Jacq., breeding, seed production, variability.

1-16-1 Use of Intergeneric Hybrids in Grass Breeding

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A breeding programme on intergeneric hybridization of both *Lolium perenne* L. and *L. multiflorum* Lam. with *Festuca arundinacea* Schreb. was initiated at Oak Park in 1970. The objective is to combine the rapid establishment, high production in the first growing season, sward density, tillering capacity and high quality of *Lolium* with the high persistency, winter hardiness, summer and autumn growth and drought resistance of the *Festuca* parent.

More than 400 crosses were made in which the female parents were selected from a number of European cultivars and ecotypes of both *Lolium* species and the male plants were taken from populations of cultivars and ecotypes of *F. arundinacea* introduced from Europe, North Africa and the U.S.A. A modification of the colchicine technique used to treat germinated seeds increased the number of fertile amphiploid plants but the percentage of the latter relative to the total number of plants which survived was low. Treatment of tillers from male-sterile field-grown F_1 plants was conducted in March 1980 and the results are promising.

Three hundred and seventy male-sterile F_1 plants with large and soft leaf blades at the primary growth and subsequent regrowths were selected after 3 years and then cloned. In 1978, 331 plantlets from some of these clones were crossed with 42-chromosome plants from populations of four synthetics - Ky 37 Gl-305, Ky 46 Gl-316 Ky 46 Gl-317 and Kenhy 45 Gl-298, produced by R. Buckner, and nine synthetics from trispecific hybrids developed by A.W. Hovin and Helen Hill. Two hundred and fifty-six hybrid plants from 160 crosses were submitted to pollen tests and their chromosome number counted in root tips. More than 80% of these plants have 42 chromosomes and are fertile, and 78% of them have more than 70% round and completely-stainable pollen grains. The other plants are male-sterile and have chromosome numbers varying between 28 and 35. These results agree with those reported by Berg, Webster and Jauhar when F_1 male-sterile plants were backcrossed to *F. arundinacea*. This indicates that the contribution of *Lolium* species in those synthetics is possibly very small.

A number of those hybrid plants was tested for perloline, N-acetyl loline and N-formyl loline contents. The results show a large variability among the plants for alkaloid content and also demonstrate the possibility of selecting plants with a low content of all three alkaloids. *In-vitro* analyses showed that the D-values varied between 59.9 and 69.8. However, no relationship between alkaloid content and digestibility could be established.

The current work indicates that the use of a wide gene-pool, selection of the most suitable parents, efficient colchicine treatment, chromosome counting and selection of amphiploids having superior agronomic characteristics, would all assist in the production of new and improved grass cultivars which would replace with advantage existing ryegrass and tall fescue cultivars.

Key words: intergeneric hybrids, *Lolium* x *Festuca* hybrids, grass breeding, amphiploids, alkaloids, digestibility.

1-16-2 Growth and Development of Two Echinochloa Millet Species in a Warm Temperate Climate

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Most summer growing forage crops fall into either the sorghum or millet species group. Included in the millet group are two species Echinochloa utilis and Echinochloa frumentacea commonly known as Japanese barnyard millet and Indian barnyard millet respectively. These species have a negligible HCN potential and higher nutritive value than Sorghum species. However, they generally flower early, yield less than forage sorghum, and lack vigour in regrowth. In this study the pattern of growth and development of two Echinochloa millets was examined as part of a larger programme aimed at improving the production of these forage species.

E. utilis cv. Shirohie and E. frumentacea cv. White panicum were grown under surface irrigation at Trangie (32°S, 148°E). Mean weekly maximum and minimum temperatures ranged from 38/19°C to 28/14°C during the growing period. Uninterrupted growth was measured by sampling every two weeks; regrowth from sampled areas was measured at the end of the growing season. Leaf area was determined and the dried plant fractions were weighed and analysed for nitrogen, sodium and sulphur.

The maximum growth rate and dry matter yield of E. utilis (30 g/m^2/day and 11.7 t/ha respectively) were greater than for E. frumentacea (11 g/m^2/day and 5.9 t/ha respectively). Morphological features including a prostrate growth habit and smaller leaf size were associated with the low yields of E. frumentacea.

Late flowering in E. frumentacea (20 days later than E. utilis) indicated delayed elevation of the apical meristem; regrowth was better in this species. When the extent of tiller decapitation was equivalent in both species, regrowth yields were similar. To obtain good regrowth it is necessary to cut or graze a crop of E. utilis before 7 weeks. Alternatively regrowth may be improved by obtaining cultivars which flower later and/or tiller more extensively.

E. utilis was higher in sodium and sulphur than E. frumentacea; nitrogen contents were similar. Mineral concentrations changed with time and, especially with sodium, differed between plant parts. For both species mineral levels exceeded animal requirements although the N/S ratio for E. frumentacea was marginal.

Important agronomic differences between the two Echinochloa millets have been elucidated. The characterisation of growth and development has demonstrated how high forage yields in these nutritional desirable species may be obtained.

Key Words: Echinochloa utilis, Echinochloa frumentacea, barnyard millet, growth, development, morphology.

1-16-3

Carbohydrate Content and Some Anatomical Properties of Grass Cultivars

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The researches concerned quantitative and qualitative ratios in carbohydrate group, of Dactylis glomerata, Festuca arundinacea and Lolium multiflorum varieties. The carbohydrate and lignin content was determined during vegetation, in three regrowths, in vegetative phase, in the stage suitable for grazing. Moreover, the carbohydrate and lignin distribution in plant above-ground mass, in earing phase, was determined. In order to denote the occurring dependencies, the anatomical examinations of leaves were carried out by measuring the characteristic features of epidermis, mesophyll, sclerenchyma and vascular bundles.

On the ground of results of mean content of carbohydrates and their accompanying lignins, Lolium multiflorum varieties deserved highest positive evaluation, in contradistinction to Dactylis glomerata and Festuca arundinacea. Generally, Lolium multiflorum varieties proved to have higher sugar content at lower cellulose content. The mentioned favorable set of some Lolium multiflorum varieties is conspicuously marked, for example Ninak variety. As concerns the hemicelluloses content, Festuca arundinacea varieties had a higher percentage, in contradistinction to Lolium multiflorum varieties.

The analyzed anatomical characters stress again the higher alimentary value of Lolium multiflorum varieties, which have the relatively smallest surface covered by sclerenchyma and vascular bundles on cross section of leaf blade, at the greatest mesophyll thickness. Moreover, the significant differences between varieties in the scope of species, in leaf anatomical structure, are found, which in connection with dependence upon chemical composition, may be used in labors concerning the improvement of varieties destined for fodder production.

Key words: Dactylis glomerata, Festuca arundinacea, Lolium multiflorum, carbohydrates, lignins, leaf anatomical structure.

1-16-4 Summer Dormancy in Italian Populations of *Dactylis glomerata* L.

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Mediterranean types of perennial grasses are winter growing and summer dormant while Central and Northern European types are winter dormant and summer growing. Dormancy severely limits the annual production and largely determines the seasonal pattern of yield distribution.

Summer dormancy was studied in 81 Italian populations of *Dactylis glomerata* L. collected from North (48°N) to South (38°N) of the Italian peninsula. Dormancy was measured at Perugia 43°05'N on 60 plants for each population. All plants with nonvisible green leaves in summer but regenerating in the following autumn were classified as dormant; the amount of green foliage in summer after a July cut was taken as a measure of the degree of physiological activity of the plants. The same plants were scored for winter growth and greenness in December. The percentage of summer dormant plants of the 81 populations was correlated with the mean score for their summer growth ($r=-0.75^{**}$) indicating that dormancy can be evaluated also when the climatic conditions do not permit the sharp distinction between dormant and nondormant plants. The results have permitted us to distinguish three main groups of populations with increasing level of summer dormancy, namely northern, central and southern. Winter growth and greenness was negatively correlated with summer growth ($r=-0.80^{**}$). The greatest variability among populations was observed in the southern group for summer dormancy and in the northern group for winter growth; the central group showed intermediate degrees of dormancy in both periods. Among Italian populations of *Dactylis glomerata*, variability for dormancy, both in summer and winter, is so high that breeding of adapted varieties with the desired growth rhythm should not be difficult. For the specific requirements of a given area the level of dormancy of the local population seems to be too high, and therefore the base population for breeding purposes should be chosen among those found in localities with less severe climate and more fertile soils.

Key words: orchard grass, *Dactylis glomerata* L., summer dormancy, Italian populations.

1-16-5 Selection for Seedling Vigor in Russian Wildrye

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Improving stand establishment capability is an important objective of most forage grass breeding programs. We ascertained the value of using seed weight and coleoptile length, two highly heritable and easily measured traits, as selection criteria for improving seedling vigor of Russian wildrye (Elymus junceus Fisch.).

Large, medium, and small seed size categories each consisted of 10 seed lots that were derived from 10 open-pollinated plants selected from a population with a wide gene base. Average seed weights from the 10 plants within each seed size category were 4.2, 3.2, and 2.4 mg/seed for large, medium, and small seeds, respectively. Coleoptile length of the 30 genotypes ranged from 40.7 to 54.6 mm, and the correlation coefficient between coleoptile length and seed weight was 0.69. Coleoptile length of large and medium seed size categories differed non-significantly by 2.3 mm, but the average 4.2 mm difference between medium and small seed was significant.

Emergence from deep planting was measured from seeds placed 5 cm deep in soil maintained near field capacity in the greenhouse. Emergence was low for seed lots with low seed weight and coleoptile length averaging less than 45 mm. Large and medium size seeds were not significantly different in rate of emergence or total emergence. Foliage dry weights recorded 70 days after planting averaged 3.7, 2.7, and 1.3 g/plot for large, medium, and small seed size categories, respectively.

Emergence from a 2.5 cm depth in finely ground vermiculite maintained at -5, -7, and -9 bars of matric potential was significantly lower for the small seed size category, but the difference between large and medium categories was not significant. Emergence of genotypes under high drought stress (-9 bars) was not closely related to emergence response at -7 and -5 bars of matric potential. The large range among genotypes in rate of emergence and total emergence at -9 bars of matric potential suggested that genetic variability may be present for physiological processes that condition cell division and elongation under drought stress.

The small seed size category was significantly lower in emergence percentage than medium and large sized seed in one field environment, but no significant difference in emergence among the seed size categories was detected in a second field environment. High experimental error and genotype-environment interactions indicated that a high number of replications and test environments are needed to measure differences in seedling vigor in field studies.

Genotypes with seed weights averaging less than 3.0 mg and coleoptile lengths less than 45 mm were low in both rate of emergence and total emergence when tested in controlled environments. We concluded that seedling vigor of a population of Russian wildrye would be improved by first discarding genotypes with low seed weight followed by selection for increased coleoptile length.

Key words: Russian wildrye, Elymus junceus Fisch., coleoptile stand establishment, seedling vigor, seed weight.

1-17-1

New Efforts of Forage Cereal Breeding in Eastern Canada

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Annual forage cereals have been used in Canada for a long time but efforts to breed special cultivars for forage purposes are relatively new. Demands for such cereals are particularly high in Western Canada which has a large livestock production and where most of the testing is being done. However, it is in Eastern Canada where efforts for breeding such specialized cereal cultivars have been intensified recently.

The first forage cereal cultivar released in recent years in Canada was Foothill oats from Ottawa (Burrows, Canadex 1978), a dual-purpose selection with interspecific background which yields only about 7% less grain but 20% more digestible dry matter per hectare than comparable controls, as confirmed by extensive testing in Western Canada. The next species with claims for use as a forage cereal was triticale, both winter and summer types, produced by Mr. S. Symko at Ottawa before his retirement. From a large collection, 30 samples were selected for satisfactory grain yield, and sent to Lacombe for testing in 1979. Of these 30 samples, two were winter types, with no data available as yet, 17 were spring types and the others intermediate. Five of the spring types proved very promising, combining high grain yield with high dry matter production, compared to other cereals, including six triticale selections of intermediate type from Guelph University, two of which were released as new cultivars in 1980 by Drs. E. Reinbergs and V. Poysa. The barley work was started by Dr. G. Fedak, and continued by S. O. Fejer who added many awnless and hooded introductions obtained from Dr. E. Ulanska, Freising, W. Germany. Some of the latter types are in advanced stages of reselection and testing, both in the growth rooms and in the field at Ottawa, and at Lacombe. In comparison to forage oat material, barley provides high forage yield with high digestibility and protein content (highly positively correlated to each other) combined with acceptable grain yield. New cultivars should be available for release in a few years

Thanks are due to the Government of Alberta for a special grant for testing forage cereals, and to Dr. F.S. Warren, Ottawa, for digestibility tests.

Key words: forage cereals, barley, oats, triticale, breeding.

1-17-2 Studies on 25 Varieties of Elephant Grass (*Pennisetum purpureum* Schum)

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The present experiment was carried out during the years 1975-1978 to (a) identify twenty-five cultivars of elephant grass through their morphology; (b) to study the chromosome numbers of the cultivars; and (c) to evaluate the adaptation of the varieties to low and to high levels of management (cutting), measuring their dry-matter production and *in vitro* digestibility. The low level of management involved pre-determined cuts at 5-10 cm from the ground, and the high level involved cutting the plants of each plot back to 0.40 cm from the ground when they reached 0.80 cm height.

From the morphological studies we found that differentiation of the cultivars was very difficult but that with much practice it was possible to identify the following cultivars: Uruckwami, Cameron, Porto Rico, and Common napier. In chromosome number all the cultivars had 2n=28 except the hybrid Bajra N.B., which had 2n=21. In the study many species demonstrated large seasonal production. The varieties with the best winter production for the two levels of management were, respectively: Taiwan A-144, Taiwan A-143, Elefante mineirão C.E., Common Mercker, Mole volta grande, Taiwan A-241, Cameron, plot number 4, and Bajra N.B.21. The varieties with the best summer production for the two managements were, respectively: Taiwan A-144, Elefante mineirão C.E., plot number 6, Elefante mineiro, plot number 9, Taiwan A-241, Cameron, plot number 4, and Bajra N.B.21.

From the results we concluded that (a) identification of the cultivars is very difficult; (b) the chromosome number of all the varieties except Bajra N.B. is 2n=28, while that for Bajra N.B. is 2n=21; (c) the high cutting resulted in the highest yields but also led to the greatest reduction in yield from one year to the next; (d) the best cultivars for low cutting during the dry season were Taiwan A-144, Taiwan A-143, Elefante mineirão C.E., Common Mercker, and Mole volta grande; and (e) for high cutting during the dry season the best were Taiwan A-241, plot number 4, Cameron, and Bajra N.B.21. The best management was cutting high except at the beginning of the dry season, when results were best with the low cutting.

Key words: elephant grass, *Pennisetum purpureum* Schum., varieties, morphological characteristics, chromosomes number, management, bromatological composition, *in vitro* digestibility.

1-17-3 Characterization of Three Outstanding Species of Cynodon Genus in Introduction Fields

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Three outstanding species of the Cynodon genus (Coastal bermuda grass) were studied for three years with two levels of nitrogen (N) (N_1 200 and N_2 400 kg/ha/year) with the aim of characterizing their seasonal yield potential (dry matter DM/ha) and their crude protein composition percentage (CP), phosphorus (P) and calcium (Ca). The experimental work was carried out in a latosolic soil, using a factorial design with four replications. The three species were cut every 36 days at 5 cm height in the rainy season and every 45 days at 10 cm during the dry season. In this latter season irrigation was applied. All the treatments received P and K at a rate of 50 and 100 kg/ha/year. N_2 (24 t DM/ha) was significantly superior ($P<0.001$) to N_1 (17 t). With N_1 the species were significantly different ($P<0.001$), with B. swanee yielding 19.4, Coast cross bermuda grass 16.3, and Coastal bermuda grass 14.0 t/DM/ha. In turn, with N_2 Coastal bermuda grass was poorer (22 t DM/ha) than the other two species (24.7 t DM/ha). CP percentages were more affected by the season of the year (11.5 and 7.0% for the rain and dry seasons, respectively) than by N application (9.1 vs 9.5% for N_1 and N_2). No significant differences were found between species. P percentage was 0.23, 0.22 and 0.20 for Coastal bermuda grass, Coast cross bermuda grass No. 1 and B. swanee grass. The three species had similar values of Ca (0.46%). Both elements were affected by the season, with P values of 0.24 and 0.19% and Ca values of 0.40 and 0.50% for the dry and wet seasons, respectively. It can be concluded that B. swanee and Coast cross bermuda grass No. 1 with 200 kg of N/ha can offer high yields with an adequate CP, P and Ca composition, making possible a good conversion of N applied.

Key words: Coastal bermuda grass, Coast cross bermuda grass No. 1, B. swanee grass, nitrogenous fertilizer, mineral composition.

1-17-4 Forage Plant Germplasm Collection, Evaluation and Utilization in the Well-Drained Tropical Savannas of Colombia

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Some 300 million hectares of extremely infertile grasslands stretch across the lowland tropics of Latin America. Although these ranges support about one half of the 160 million cattle found in the region, productivity is generally now. Poor nutritive value of native pastures is the principal cause of this low productivity. A fundamental approach in correcting these nutrient deficiencies is through the establishment of improved pastures based on legume-grass mixtures.

In 1974, the Centro Internacional de Agricultura Tropical (CIAT) initiated a coordinated program for the systematic collection, introduction and conservation of selected forage legumes and grasses in tropical America. During 1975, CIAT directed extensive forage legume explorations under the sponsorship of the International Board for Plant Genetic Resources. After 1976 this work continued as a full program of CIAT.

Data on the performance of species in clipping trials and under actual grazing conditions are presented. The experiments were sited at Carimagua, 350 km east of Villavicencio, near the Meta-Vichada border at lat.4° 34' N, long.71° 20' W in the Llanos Orientales of Colombia. Altitude: 160 m, annual rainfall: 2100 mm. The soil is an acid (pH 4.1)Oxisol, Al saturation: 86.5 .

In search of accessions with higher yields, resistance to pests and diseases, a randomized complete block design with four replications was used to evaluate 73 accessions of Stylosanthes capitata and eight of S.macrocephala. In another experiment 40 accessions of Centrosema spp. including C.acutifolium, C.brasilianum, C.macrocarpum, C.pascuorum C.pubescens and C.virginianum were tested in small sward plots.

Under grazing as well as cutting regimes the late and mid-season flowering accessions of S.capitata produced more dry matter than the early flowering accessions and S.macrocephala. Accessions of C. brasilianum and C.macrocarpum were the highest yielding of the Centrosema species under cutting treatment.

Grazed pastures of 9 ecotypes of S.capitata, each in mixtures with Andropogon gayanus or Brachiaria decumbens, produced presentation yields (DM) up to 19.5 t/ha year with a legume content of 36 and 48% respectively.

Desmodium ovalifolium, an Asiatic species of the genus, was the most persistent legume in association with B.decumbens and B.humidicola. During the second year following establishment legume content of the two mixtures increased from 38% to 49 and from 30% to 36 respectively. S.capitata and D.ovalifolium produced similar herbage yields in association with A.gayanus, both legumes outyielded D.heterocarpon cv.Florida.

Several legume species show considerable potential for the savanna regions of tropical America and commercial cultivars are likely to be released in the future.

Key words : Stylosanthes, Centrosema, Desmodium, Andropogon,Brachiaria, germplasm, savannas.

2-1-1

Trials on Time of Nitrogen Application in the Spring to various Grasses Grown for Seed Production

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With most of the grasses grown for seed in Denmark a series of trials has been carried out on increasing nitrogen rates in the autumn combined with increasing rates in the spring. The results of these trials show that an autumn application of nitrogen is very important to most of the grasses and necessary if the optimum yield of seed is to be achieved.

In order to find the best time of applying nitrogen in the spring when producing grass seed, a number of trials have been carried out in the recent years with various grasses. Up to and including 1980 the following number of trials on the time of nitrogen application have been carried out: with Festuca rubra, 29; Dactylis glomerata, 28; Poa pratensis, 4; Lolium perenne, 13; Festuca pratensis, 23; Phleum pratense, 22; and Phleum bertolinii, 6.

The first application took place as soon as the winter was over and it was possible to drive in the field; the second application was made when the growth had started and the third application when the new tillers were about 15 cm long. The average dates of nitrogen application to Festuca rubra were March 2nd, April 1st and April 30th, and this comes very near the averages for the other grasses.

The results show that the time of nitrogen application in the spring is of great importance for the development of the grass. A delay in nitrogen application to most of the species resulted in a negative effect of varying degrees on the number of fertile tillers/unit area, but a positive effect on the seed weight and the number of seeds per fertile tiller.

The result of these effects on the yield components was a decrease in seed yield of Festuca rubra, Dactylis glomerata and Poa pratensis, but an increase in yield of Phleum pratense and Phleum bertolinii. As for Lolium perenne and Festuca pratensis the positive and negative effects on the yield cancelled each other out and so the seed yield did not depend on the time of nitrogen application.

On the basis of these results it must be recommended that nitrogen be applied in the spring to Festuca rubra, Dactylis glomerata and Poa pratensis as soon as the winter is over and to Festuca pratensis and Lolium perenne as soon as growth has started, but to Phleum pratense and bertolinii (which ripen late) not until the growth is well under way and the grass has tillers about 10 cm long.

Key words: seed production, nitrogen, time of application, grasses.

2-1-2 Influence of Grazing Management and Nitrogen Fertiliser Application on Seed and Animal Production from Nonspecific Swards of *Festuca*, *Dactylis* and *Phalaris* in South Australia

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Pasture seed and livestock production are integrated in certain countries. The animal is used as a defoliator and animal production is a byproduct from the seed crop. Perennial grass seed crops are usually grazed for all or part of the period beginning soon after seed harvest (in order to remove crop residues) and during vegetative growth (to stimulate tillering and reduce lodging) until the time of early reproductive development of the grass. If grazing animals ingest developing seedheads, these seedheads are lost for seed production. Little information is available on the effects of the duration of grazing, stocking rate, and time of removal of grazing animals on the nitrogen (N) requirements, seed yield and animal production from perennial grass pastures.

Field trials were conducted in a Mediterranean-type environment in South Australia aimed at defining optimum levels of grazing and N fertiliser management practices to obtain maximum animal production without reducing grass seed yield. The main treatments applied involved the use of five closing times (i.e. 5 times of removal of grazing animals), three stocking rates (0, 15, and 30 sheep/ha) and three N rates (0, 75, and 150 kg N/ha). The treatments were applied in three separate, identical trials repeated over two years on established swards of tall fescue (*Festuca arundinacea* cv. Demeter), cocksfoot (*Dactylis glomerata* cv. Currie), and phalaris (*Phalaris aquatica* cv. Australian). Further details of the design, measurements and preliminary results for tall fescue have been presented by Williams and Boyce (1977, Proc. XIII Int. Grassland Congress, pp. 506-512).

Time of closing was the dominant factor influencing seed yield and animal production from the three grass species studied in both years. In general for each species the intermediate time of closing (i.e. early September) produced the maximum seed yields and there were substantial reductions in seed yields if grazing was prolonged further. Ungrazed treatments produced similar or slightly less seed compared to the intermediate time of closing, for all species. Presumably some early season grazing is desirable to remove excess plant growth and establish a uniform canopy, to stimulate tillering and to reduce lodging. Animal production increased as the time of closing was delayed and with increased stocking rate. However, grazing should be curtailed as soon as significant reductions in seed yield occur. Stocking rates of 15 and 30 sheep/ha produced similar effects at each time of closing and each N treatment in all species.

In general a minimum of 75 kg N/ha was required for maximum seed yield in all treatments. There was a trend for increased response (in terms of seed yield) to N applied at rates up to 150 kg/ha (the highest rate used), as the time of closing was progressively delayed and as stocking rate was increased.

Key words: seed yield, *Festuca arundinacea*, *Dactylis glomerata*, *Phalarus aquatica*, nitrogen grazing rates, grazing duration.

2-1-3

Post-harvest Residue Burning as a Management Tool in Grass Seed Production

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Post-harvest residue burning, initiated in Oregon in the early 1940's to control blind seed disease in perennial ryegrass, has been found to be a most effective field sanitation method which also enhances seed yield. It is now a general practice in Oregon and its use is expanding to other regions.

Questions of how burning beneficially affects grass seed crop production have been the focus of many studies conducted over several years in the Willamette Valley. These studies were given emphasis by the concern for clean air in certain locations in Oregon. The objectives of the research were to: (1) document the yield response of different species and varieties to post-harvest residue burning over a several year period, (2) compare burning to alternative methods, such as mechanical removal for effectiveness in maintaining seed yield, (3) evaluate relationships of time of burning to subsequent crop yield and (4) determine effects of burning on growth characteristics related to seed yield.

Investigations were carried out over a several year period examining response to burning and mechanical residue removal of different grass species and varieties in experimental plots at various locations in the Willamette Valley. Results indicate that most species and varieties respond positively in terms of seed yield; however, some show a greater yield response than others. Forage type perennial ryegrass, orchardgrass, tall fescue, and bentgrasses are less responsive to residue management as compared to fine fescue. Varieties within species respond differently to burning, but in general more effective residue removal results in higher seed yield. Increases in fall tillering and earlier emergence of a larger number of panicles is the basis for seed yield increases in response to burning. Weed control is improved by post-harvest burning with greater numbers of weeds surviving where mechanical methods of residue removal are practiced.

Burning early when straw moisture is low and before regrowth starts gives superior yields. Late burning when regrowth has developed and moisture content is greater can cause stand injury and is less effective in removing residue. Alternate year burning is undesirable from the standpoint of seed yield and disease control. Smoke management by timing of burning to favorable meteorological conditions for smoke dispersion, is aiding the continuation of post-harvest residue burning practice by reducing the impact of smoke in population centers.

The wide spectrum non-residual pest control and yield stimulation provided by post-harvest burning makes it an extremely important management tool for grass seed crops in Oregon and elsewhere that climate permits.

Key words: cool season grasses, seed yield, tillering, panicle emergence, cultivars.

2-1-4 Effect of Autumn and Spring Defoliation and Defoliation Method on the Seed Yield of *Lolium perenne*

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Trials in 1979 and 1980 evaluated the effect of autumn and spring defoliations on fertile apex removal, tiller survival, seed yield components, and seed and forage yield in two amenity and one agricultural-type perennial ryegrasses (*Lolium perenne*), established in the autumn. Methods (reciprocating mower or sheep), height (3-5 cm or 6-8 cm) of defoliation and the addition of supplementary nitrogen (N) after defoliation were evaluated in the variety Royal in 1980.

In both years and all varieties, autumn defoliation had no significant effect on seed yield. With the exception of Royal in 1980, seed yields were reduced by cutting if carried out after spikelet initiation due to an increase in apex removal, particularly in autumn-emerged tillers. In Royal in 1980, survival of spring-emerged tillers as mature ears at final harvest was increased by defoliation at floret initiation, and this compensated for tiller loss.

Seed yield reductions were accompanied by decreases in all yield components except 1000-seed weight in both years and seeds/spikelet in 1980.

Supplementary N failed to compensate for yield loss but cutting high (6-8 cm) at floret initiation produced 1.2 t/ha of dry matter with reduced apical loss. Spring forage yields in all varieties and all yields were increased by later cuttings.

Defoliation in autumn-established crops is unnecessary. However, growers with forage requirements may safely defoliate up to spikelet initiation and obtain approximately 2 t/ha of dry matter from these varieties.

Key words: ryegrass, seed production, defoliation, tillering.

2-1-5 Seed Production for the Establishment of *Pennisetum americanum* x *P. purpureum* F_1 Hybrid Pastures

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Several genotypes among the interspecific F_1 hybrids between 'Maiwa', a short-day photoperiod-sensitive local cultivar of pearl millet (*Pennisetum americanum* (L.) K. Schum.) and elephant grass (*P.purpureum* Schumach) produced at the University of Ibadan, Nigeria, combine the high dry matter yield potential and perenniality of elephant grass with greater acceptability to livestock and increased digestibility resulting in higher liveweight gains compared to elephant grass. Though sterile, the F_1 *Pennisetum* hybrids are easily propagated vegetatively. Distribution over a wider area of adaptation can be facilitated by large-scale F_1 seed production utilizing cytoplasmic male-sterile pearl millet.

Cytoplasmic male-sterile Maiwa was developed by transferring male-sterility factors from Tift 23A pearl millet through a backcrossing procedure.

Male-sterile Maiwa was grown between rows of six elephant grass ecotypes which combine well with it, in a 358-m^2 plot. To ensure coincidence of flowering with elephant grass, Maiwa was sown at the end of August.

Seed head diseases, the most serious being ergot (*Claviceps* sp.), resulted in heavy losses and 3.17 kg of F_1 hybrid seed was recovered. This is equivalent to a production of 88.5 kg/ha of hybrid seed, adequate to establish 8 ha of pasture when the seed is sown at the rate of 11 kg/ha in rows 90cm apart. At Ibadan, under ideal conditions a 1.60-ha multiplication nursery is required to establish the same acreage vegetatively.

The study has shown that large-scale production of the F_1 *Pennisetum* hybrid seed is practicable. A much higher seed yield can be expected if diseases prevalent in the humid environment of Ibadan can be contained. Seed production in less humid regions where pearl millet is normally cultivated should minimize the problem.

Key words: *Pennisetum* hybrids, seed production, seed yields.

2-2-1 Alfalfa Seed Production Evaluation, Harvested and Theoretical, at Different Nutritional Levels

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The research done under irrigated conditions at Fundulea (Romania) in two growing seasons, 1977/1978, was designed to determine the best nutritional space for alfalfa (Medicago sativa L.), variety Luxin, cultivated for seed production.

The trials were established in a randomized block design, with four replications and the following variants: (V_1) - 50 cm between the rows, 2 cm on the rows, (V_2) - 75 cm x 2 cm, (V_3) - 100 cm x 2 cm, and (V_4) - 125 cm x 2 cm.

The number of stems was recorded in one meter, the number of racemes on one stem, the number of flowers in one raceme, the number of flowers in one meter and the number of flowers in one square meter.

Based on this data, the theoretical seed yield was calculated and compared with the harvested yield.

It appears that in alfalfa seed production, the best distance between the rows is 50 cm and between the plants on the rows 2 cm, that is 100,000 plants per hectare.

The data obtained are significant to propose a new method, simple, correct and useful at the farmer level, for seed production evaluation in the flowering time, about one month before harvesting.

Following this method, the number of millions of flowers per hectare give directly the number of kilos seed per hectare. The seed production evaluation obtained with this method could outyield the harvesting seed production by 32 - 49 %, unrelated to the size of the nutritional space.

Key words: alfalfa (Medicago sativa L.), nutritional space, Luxin, seed production evaluation.

2-2-2 Intensity of Defoliation and Its Effect on Top and Seed Production of Subterranean Clover in Spain

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The objectives were to determine the effects of intensity of defoliation on seed production and on other parameters such as seed weight, seed viability and amount of buried and soil surface seed.

For this purpose, two species of subclover were chosen, Trifolium subterraneum and Trifolium brachycalcinum, the first one widely used in Australia and with many cultivars available on the market and the second one with only one cultivar (Clare) on the market, but widely represented spontaneously in S.W. Spain, to determine a possible difference in the behavior of these two species.

The experiment took place in Olivenza (Badajoz). Thirty-two random plots, each 3 x 3 m, were sown in the beginning of October 1977. Sixteen of them included a mixture of Daliak, an Australian cultivar, and Victor, a Spanish one, and the others were sown with a mixture of Clare, the only Australian "brachy" cultivar, and L.O. 11, a Spanish selection.

Germination rates and seed weight were measured for each variety before sowing in order to have the same amount of seedlings within each mixture. The same sowing rate was used in both species.

The experiment included four defoliation intensities ranging from non-defoliation during the whole life cycle to weekly defoliations.

The treatments were as follows: (a) weekly cuts till the end of life cycle; (b) monthly cuts till the end of life cycle; (c) monthly cuts till the beginning of flowering; and (d) no cuts at all during the whole life cycle.

The material collected on each cutting was oven-dried and weighed, as was the top growth remaining on each plot at the end of season. Seeds were collected from random 0.25 x 0.25 m squares on each of the 48 plots. The seeds formed on the soil surface were kept separate from those buried

Key words: subterranean clover, defoliation intensity, seed yield, seed weight.

2-2-3 Effect of Different Systems of Seed Treatment, Packing and Storage on Vigor and Germination of Five Tropical Forage Legumes

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Production of tropical forage legume seeds is expensive. Very often the establishment of mixtures is difficult due to lack of uniformity in vigor and germination of the legume seed. Treatment with chemical compounds has been reported useful to break dormancy. The packing material and temperature of storage have also been reported to affect seed vigor and germination.

To recently harvested seeds of tropical kudzu (Pueraria phaseoloides, Benth), clitoria (Clitoria ternatea, (L) Dne), Centrosema (Centrosema pubescens, Benth), siratro (Macroptilium atropurpureum Noc et Seed) and desmodium (Desmodium intortum (Miller) Urban), the following treatments were applied: concentrated sulfuric acid (96%) for five minutes at the beginning of the experiment, concentrated sulfuric acid for five minutes at planting time, hot water at 80°C for 20 minutes at planting time and untreated seeds used as controls.

The seeds were packed in paper and plastic (polyethylene) bags and stored in the greenhouse (28°C average temperature) and in the cold room (8°C average temperature). The seeds germinated in a moisture and temperature regulated germinator (27°C and 95% moisture) every 20 days for a period of six months. Results were recorded five days after planting (vigor) and 20 days after planting (germination).

Results indicated that vigor and germination increased with treatment in most of the studied species. The best results were found by soaking the seeds in hot water for 20 minutes.

In general, seeds stored in plastic bags at high temperature broke dormancy faster than seeds stored in paper bags or at low temperatures.

Treatments like sulfuric acid do not present any significant advantages over soaking in hot water.

Key words: seeds of tropical forage legumes, treatment, packing, storage, vigor, germination.

Red Clover Breeding and Seed Production in the German Democratic Republic

2-2-4

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In the GDR, red clover is grown in pure stands and in clover/grass mixtures. It is fed to animals either fresh or as conserved forage. The diploid 'Marino' variety is well suited for one-year to eighteen-month field forage growing. The tetraploids 'Perenta' and 'Matri' lend themselves above all to two-year to thirty-month arable cropping.
It has been the breeders' task to produce diploid and tetraploid varieties for one-year to eighteen-month and for two-year field forage growing, giving two or three cuts each.
Major breeding purposes include the increase of dry matter yield, better lodging resistance, suitability for use in clover/grass mixtures, field resistance to stem rot (Sclerotinia trifoliorum), resistance to mildew (Erysiphe martii), and high feeding value. The new varieties must be sufficiently winter-hardy and ensure high seed yields, particularly in tetraploid forms. These objectives shall be met through the development of new polyploid basic material, experimental use of species hybrids, and development of synthetic strains.

As red clover seed production is started even before national approval, the area grown to new varieties can be rapidly extended. Seed growing in the GDR is accomplished according to industrialized production methods. The fields for red clover seed growing are mostly between 150 and 200 ha in size, depending on the requirements of combine-harvesting following chemical siccation.

Seed yields of 0.25 t/ha as a minimum can be achieved if the following requirements are met: sowing in due time, mostly under spring barley; cutting for forage on schedule by the end of May in the year of seed use; use of eight bee colonies per one hectare; threshing with rubbing cloth; artificial seed drying in the case of adverse weather conditions. In this way it was possible in recent years to continuously raise seed yields, to provide seed of the best varieties to the socialist farms, and to make clover seed available for export.

Key words: red clover (Trifolium pratense), varieties, breeding purposes, seed production.

2-2-5 Effect of Laboratory Alternative Temperatures on Retention of Hardseededness in Siratro

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The contribution from hard seeds during establishment of pasture legumes requires more positive documentation. Temperature is one of the most important factors influencing the reduction of hard-seededness in the field. High temperatures can also be used to reduce the proportion of hard seeds prior to sowing.

The responsiveness of hard seeds of Siratro to alternating temperatures was measured to -

(i) gain greater understanding of the contribution they could make during pasture establishment phase, and

(ii) determine the possibility of using a pre-sowing heat treatment.

Seed of nine samples of Siratro (Macroptilium atropurpureum cv. Siratro) were subjected to four temperature (C) regimes (25°, 15°/45°, 15°/60°, 15°/70°, 16 hours at the lower temperature, 8 hours at the higher one) for periods of one to eight weeks. Seed was then germinated for a period of 56 days on moist germination paper at 25°.

Heat-treated seeds did not imbibe as readily as untreated seeds. However, in the 8-56 day period, substantial numbers of heat-treated seed imbibed whilst very few untreated seed did so. As a consequence, alternating temperature treatment significantly reduced hard seed content at 56 days (15°/70°, 15°/60°, 15°/45°) for all samples.

Although there was a significant response to extending the duration of the day-heat treatment beyond one week, the response was very small in comparison with the effect of the one week treatment.

A high proportion of hard seeds of Siratro can be made permeable by exposures to temperatures which commonly occur in exposed situations during summer in tropical and subtropical regions. The significance of this finding is discussed in terms of pasture establishment practices and management strategies aimed at Siratro persistence.

If Siratro seed is to be sown under conditions such that lower temperatures will prevail, high temperature treatments can be used to reduce the level of hardseededness before sowing.

Key words: Siratro, hardseed, heat treatment, germination.

2-3-1 Inefficient Conversion of Floret Populations to Actual Seed Harvested in Grass Seed Crops

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Seed recovery, defined as 'the estimated number of seeds obtained, after machine dressing, from every 100 florets produced in the pre-flowering period' (Brown 1980a), has been measured in all our grass seed production studies at Lincoln, New Zealand. It has been shown that although only a small proportion of each year's floret population is incapable of producing seed, recoveries greater than 34 were uncommon. Methods for determining floret and seed numbers are given.

In ryegrass (Lolium sp.) crops the larger the floret population the lower the recovery. The relationship was curvilinear and, with a linear term of nitrogen (N) included, 87% of the variance in recovery was accounted for. Although the negative effect of high floret numbers was ameliorated by N, recovery was low, averaging 23.3 ± 1.0. Floret conversion was inefficient.

'Grasslands Matua' prairie grass (Bromus catharticus Vahl.) floret conversion was also inefficient at 20.8 ± 1.6 mean recovery. In these trials recovery (1) increased with increasing row spacing, and (2) increased as rate of elongation N increased above 10 to 80 kg/ha. As in the ryegrass work size of floret population was an important factor affecting recovery. However, the amount of N available to counteract N-induced increases in floret numbers was important.

Recovery declined as row spacing increased in a first year crop of 'Grasslands G17' cocksfoot (orchard grass) (Dactylis glomerata L.). Here floret populations were highest at wider row spacings, e.g. 45 cm, 515 x 10^3 florets/m^2 with 9.9 recovery compared with 280 x 10^3 florets/m^2 with 17.4 recovery at 15 cm spacing.

There can be little doubt that recovery was poor and floret conversion inefficient and that the size of the floret population was an important determinant of recovery. Research aimed at inhibiting reduction in and/or increasing recovery offers a promising approach for increasing the efficiency of grass seed production. Understanding and manipulating the floret x N interaction and a thorough knowledge of appropriate methods of harvesting are suggested as two approaches which may lift recovery beyond 40.

Key words: ryegrass, Lolium, prairie grass, Bromus catharticus, cocksfoot, Dactylis, seed yield, floret populations, seed recovery.

2-3-2 Selection for Seed Retention in *Phalaris aquatica* L.

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Seed shattering is a problem in most pasture grasses, especially in those that have a recent history of domestication. In many of these, losses from shattering are aggravated by uneven ripening of inflorescences and a low percentage of viable seed.

Fragility of the rachilla appears to be the most common cause of seed shattering in grasses, and once this connection is broken, the seed is free to shed from the inflorescence. In some of the more domesticated species, the nature and configuration of the glumes and the manner in which they are packed on the inflorescence play an important part in retaining seed.

Attempts to reduce seed shattering in phalaris (*Phalaris aquatica*) by selection for a more compact and inflexible inforescence have been successful, as has the development of special harvesting machinery and the use of sprays to bind the inflorescence and prevent seed fall.

The most successful approach, however, has come through the discovery of a natural seed retaining mutant within the Australian cultivar of phalaris, possessing a strong non-brittle rachilla which anchors the seed in the spikelet at maturity. This character has now been incorporated into a new seed retaining cultivar which can be harvested without suffering any significant loss of seed for a period extending for at least three weeks after full stand maturity.

It seems possible that mutations of the type found in phalaris that prevent seed shattering may be present in many grass species, but because these mutants are at a selective disadvantage in the wild, the frequency of the genes controlling them in populations will be low. Despite this, it should be possible to locate such natural mutants in other important grasses, thereby overcoming one of the major problems inhibiting the domestication of these species for use in agriculture.

Key words: phalaris, *Phalaris aquatica* L., seed retention.

2-3-3 Selection for Seed Yield in Lolium perenne

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The main emphasis in most forage grass breeding programs is given to dry matter yield although seed yield is a very important attribute in the stages of seed multiplication of a new variety. The purpose of this research was to study the interrelationships between seed yield, 1000-seed weight, and date of ear emergence in Lolium perenne through the analysis of direct and correlated responses to one cycle of phenotypic recurrent selection.

Selection was applied on choosing the 14 plants with the highest seed yield, the 14 with the highest 1000-seed weight, the earliest 14 plants and the latest 14 (selection pressure=14%). In addition, an unselected control was established with 14 randomly chosen plants. The progenies obtained by random mating of selected parents were evaluated for all selection criteria as spaced plants in a randomized block design with 150 plants per population.

Selection for seed yield was highly effective, as shown by realized heritability (40%), correlated responses toward earliness (+7.2% of control), and 1000-seed weight (+8.8% of the control). Selection for 1000-seed weight increased the character by 10.1% with a realized heritability of 43%, and caused an increase of 54.5% in seed yield and a shift of two days toward earliness. Selection for early date of ear emergence was more effective than selection in the opposite direction; realized heritabilities were 89% and 33%, respectively. Selection for earliness was accompanied by a very high increase in seed yield while 1000-seed weight remained unchanged. By contrast, selection for late date of ear emergence was accompanied by a strong reduction of 1000-seed weight while seed yield was not significantly affected.

The results showed that a high potential for increasing seed yield is present in this population of Lolium perenne: the best selection criterion to avoid adverse effect upon forage production should be 1000-seed weight. A breeding strategy for the improvement of seed yield would involve subsequent steps, each one including one cycle of selection for 1000-speed weight followed by the evaluation of correlated responses in forage yield and seed yield. The number of steps will be mainly dictated by the correlated responses in forage yield.

Key words: Lolium perenne, perennial ryegrass, selection, seed yield.

2-3-4 Processing for High-Quality Seed of Big Bluestem and Yellow Indiangrass

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Recent reintroduction of native prairie warm season grasses for livestock forage presented seed handling problems with some species in the corn belt. Seeding of big bluestem, Andropogon gerardi Vitman, and indiangrass, Sorghastrum nutans (L.) Nash, through commonly available seeding equipment is very difficult with seed from commercial sources. Commercial seed contains significant amounts of leaf and stem particles as well as awns and other appendages still attached to the seed. Seed appendages prevent an even flow of seed through the seeding equipment. This handling problem reduces acceptability of these species for pasture forage systems. Specially designed rangeland drills are available to handle commercial quality seed rather well. Limited use of this specialized equipment makes ownership difficult to justify.

The objective of this study was to improve seed quality to increase acceptability and use of big bluestem and indiangrass in pasture forage systems.

Seed from the combine was placed in a fresh-air bin dryer. The dried bulk material was processed through a debearder. The debearded material was processed through a three-screen seed cleaner to separate clean seed from the other plant material.

Unheated air reduces seed moisture to adequate storage levels in two to three days. The mixing action of the debearder causes awns and other seed appendages to be rubbed or broken off and allows more complete separation of seed from other plant parts in the seed cleaner. Debearding and cleaning of seed resulted in significantly increased purity and germination test results. Debearded seed in storage up to three years maintained viability, so no apparent seed damage occurred with the increased processing.

Field planting of debearded seed in grain drills, gravity and broadcast seeders, and rangeland grass drills was successful with each machine. Metering sprocket changes were necessary on the rangeland drill to reduce seeding to a proper rate.

Development of a commercial supply of debearded big bluestem and indiangrass seed to be planted with commonly used equipment will greatly enhance their acceptability and use in pasture forage systems in the corn belt.

Key words: indiangrass, Sorghastrum nutans (L.) Nash, processing, seed quality, debearder.

2-3-5 Seed Production Potentials of Eight Tropical Pasture Species in Regions of Latin America

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Early identification of geographic regions providing high and consistent seed yields for species of interest, especially legumes, would be very advantageous. Our objectives were a) identify potential seed yield and the principal determinants thereof for a range of species, b) progressively determine the relative potential of distinct geographic regions, and c) stimulate emphasis upon seed production issues within pasture programs. Eight grass and legume species, either promising accessions or local cultivars, were established in replicated pure stands at five locations. Compound fertilizers were applied, including nitrogen for the grasses. Seed was harvested on one occasion each time a seed crop matured by direct manual collection or mechanical cutting and threshing. Weight of clean dry seed was recorded, followed by a purity estimation. Observations were made upon phenology and problematic weeds, diseases and insects. The field experiment is current for two years.

Maximum annual seed yield (kg/ha) and multiplication rate (ha/yr) were recorded as follows: Desmodium ovalifolium CIAT No. 350, 220 and 55; Pueraria phaseoloides common Kudzu, 135 and 34; Stylosanthes capitata, average of CIAT Nos. 1315 and 1405, 962 and 190; Zornia latifolia CIAT 728, 680 and 170; Andropogon gayanus CIAT 621, 143 and 70; Brachiaria decumbens cv Basilisk, 366 and 146; Brachiaria humidicola common, 400 and 160; Panicum maximum, average of 3 cultivars, 115 and 40; respectively. Determinants of potential seed yield recorded during 1979 and 1980 were: (a) Temporal weed dominance. (b) Lack of persistence: S. capitata CIAT No. 1405 was killed by anthracnose (Colletotrichum spp.) at Brasilia. (c) Failure to flower: D. ovalifolium and D. phaseoloides did not flower in 1979 at Brasilia and Felixlandia, probably from moisture stress before induction. (d) Reduced vegetative and reproductive vigor. Diseases such as anthracnose, sphaceloma scab, root-knot nematode, affected S. capitata , Z. latifolia and D. ovalifolium, respectively, while Urocystis and Ustilago spp. affected B. decumbens and P. maximum. Prolonged high soil moisture caused P. phaseoloides to flower and seed sparsely while moisture stress had a similar effect on D. ovalifolium. (e) Lodging. Some established stands of A. gayanus, when fertilized with nitrogen but without a preflowering cut, lodged after flowering. (f) Native plant populations of Zornia spp. reduced genetic purity at two locations.

The biological potential for seed production in each region appears favorable for particular species, e.g.: Brasilia, Z. latifolia and all 4 grasses; Chimore, D. ovalifolium; Felixlandia, Z. capitata, Z. latifolia and A. gayanus; Quilichao, S. capitata, Z. latifolia and A. gayanus; Sete Lagoas, S. capitata, Z. latifolia and the grasses. These initial results will assist researchers and producers to optimize localization and management of future production efforts with these relatively unknown species.

Key words: seed yield, multiplication rate, biological seed production potential for eight tropical pasture species.

3-1-1 Phosphorus Utilization in Grassland Ecosystems

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The process of phosphorus (P) 'fixation' by soil was for long thought to result in large losses of P and led to a common belief that plants can recover only about 10 to 25% of the applied P. Because such small recoveries were considered unrealistic and contrary to common farming experience, the efficiency of P utilisation in agricultural ecosystems has been investigated. This was done by using:

(1) a balance sheet approach in long term P maintenance trials which had reached a steady state, and
(2) published data fitted to a common nutrient cycle for non-steady state conditions.

The efficiency of P utilisation in steady state ecosystems was defined as the amount of P taken up by the plants as a percentage of the total amount of P required to maintain the available soil P pool at equilibrium.

The efficiency of P utilisation in non-steady state ecosystems was defined as plant P uptake plus gains or losses in the available soil pool, as a percentage of the total P inputs to the soil.

New Zealand evidence shows that P utilisation in grassland ecosystems ranges from 70 to 90 percent of the added and recycled P, the remaining 10 to 30 percent being lost in and from the soil. These findings have been incorporated into fertiliser recommendation schemes which are currently undergoing field testing in New Zealand. The maintenance fertiliser requirements are first determined for 90 percent of the maximum production and then calculated for other levels of production by the equation:

$$Pm = \left[\log_{10} \left(\frac{100}{100-RY} \right) \right] \times P_{90}$$

where Pm is the fertiliser required, kg P ha^{-1} yr^{-1}, for a given relative yield (RY) and P_{90} is fertiliser maintenance requirement for 90% of the maximum yield, kg P ha^{-1} yr^{-1}.

Balance sheet studies based on nutrient cycles indicate that P is utilised efficiently in most ecosystems. This finding is in conflict with traditional and still maintained theories of large-scale P fixation by soil. The concept of nutrient efficiency defined in this paper is of practical importance since it can be used to calculate nutrient inputs required to maintain steady production in any agro-ecosystem.

Key words: phosphorus utilisation, phosphorus cycling, fertiliser requirements.

3-1-2 Problems of Sardinian Pastures and Certain Aspects of Their Improvement by Fertilization

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The growth of Sardinian native pastures, owing to the Mediterranean climate and to a flora made mainly of annuals with a relatively short cycle, is very irregularly distributed. This situation becomes critical in the inner high ranges where the late fall and winter production often is insignificant and, according to the needs of the animals, is therefore insufficient for many months and largely excessive in a few of the spring ones. In these environments a basic solution has been singled out in order to regularize the forage availability during the year: haymaking of the surplus of the spring yield which could be redistributed when pasture production is at standstill, and trying to reach the highest possible yield in spring in order to obtain a great deal of stocking. The effects of mineral fertilization on the realization of the latter objective is described in this paper.

Responses of native pastures to fertilization were studied during 1975-79 in two inner Sardinian localities with application of P, K and N in a factorial combination. Fertilizer rates, times and ways of application were variable for N and fixed for P and K. The trials were freely grazed up to the beginning of spring and then were left undisturbed until haymaking at the end of spring.

The application of mineral fertilizers leads to a sharp increase of yielding capacity of native pastures. On average, during the four years the experiment, the most effective fertilizer treatments increased the forage yield by 70% in the most productive pasture and by 200% in the other one. Phosphorus proved to be the most important element in both places and in one of them, characterized by a good amount of legumes in the grass stand, it brought about the maximum increase all on its own. It also improved the botanical composition with a threefold increase of the legumes in the poorest sward and twofold increase in the other one. Potash had no marked impact on forage yield even if some differences resulted between the localities and interactions with the other elements were noted. Nitrogen effects proved to be variable according to locality, botanical composition of native sward, times and rates of application. In the winter cooler locality, where grasses were predominant, early spring application was more effective than fall application, and coupled with P produced the highest yield but made up practically of grasses alone. The effect of fertilizers on the regularization of annual yield was also evident in some treatments, although the annual production remained concentrated during the spring months.

Results of the work demonstrate that fertilization of native pastures, associated with haymaking of the spring surplus, allows obtaining a great deal of forage that can be used during periods of limited growth. These two operations are definitely a very cheap way to create a more regular feed availability to animals and, therefore, render pastoral activity in Sardinia less uncertain.

Key words: native pastures N P K fertilization, yield seasonality, haymaking, pasture management.

3-1-3 Growth and Phosphorus Concentration of *Centrosema pubescens* in Flowing Solution Culture Under Differing Defoliation Regimes

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Australia

An experiment was carried out to investigate the effect of several defoliation regimes on growth and tissue phosphorus concentration of centro grown in flowing nutrient solution at eight constant soluble concentrations, viz. 0.06, 0.24, 0.7, 3, 9, 26, 87 and 264 μM.

Each flowing culture unit was randomly assigned a soluble phosphorus concentration. Within each unit four methods of defoliation x three cutting intervals x three replications were established using a randomized block design. Phosphorus treatments were imposed 13 days after pregerminated seeds were transferred into the flowing culture units which contained basal nutrients only. Defoliation treatments were initiated 29 days later. At this time, plants were cut to stubble heights of 2.5, 7.5 and 12.5 cm, while in a fourth treatment all leaves were removed from the plants. Cutting intervals of 7, 14 and 21 days were imposed on plants in each of the four defoliation treatments over the 42 day experimental period which followed the initial defoliation. These cutting intervals resulted in 6, 3, and 2 harvests, respectively. Dry matter yields of regrowth were obtained at each harvest, while stubble roots were obtained at the final harvest only.

Maximum dry matter yields in all defoliation treatments and in non-defoliated control plants were obtained at 3 μM phosphorus. Total dry matter production decreased with lowered cutting height, the lowest top and root yields being consistently obtained at all phosphorus concentrations and all cutting intervals in the 2.5 cm cutting height and complete defoliation treatments. The effects of cutting height were particularly marked at the 7-day cutting interval. Best growth of defoliated plants was achieved with a cutting interval of 21 days and a cutting height of 7.5 or 12.5 cm.

Mean rates of phosphorus absorption were depressed by the most severe defoliation treatments, viz. 2.5 cm cutting height and the complete defoliation treatments. Death of some plants occurred in these treatments.

The phosphorus concentrations in the regrowth and whole tops of defoliated plants were always higher than those in the tops of non-defoliated control plants. Although phosphorus concentrations in the regrowth and whole tops increased with lowered cutting height following a single defoliation, subsequent defoliations decreased phosphorus concentration in the regrowth, particularly at the lower cutting heights.

Critical phosphorus concentrations, derived from relationships between plant growth and tissue phosphorus concentrations were higher in defoliated than in control plants. The critical phosphorus concentration increased with lowered cutting height following a single defoliation, but decreased with lowered cutting height following a series of defoliations. The critical phosphorus concentration also decreased with increased cutting interval in all cutting height treatments.

The agronomic implications of these findings are discussed.

Key words: *Centrosema pubescens*, soluble phosphorus, defoliation, cutting height, cutting interval, yield.

3-1-4 Availability of Soil Phosphorus to Tropical Pasture Species

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Quantitative measurements of the amount of soil phosphate available to plants were made by an isotopic dilution technique (L-value). Following very thorough mixing and equilibration of ^{32}P with soil P, sequential harvests of perennial pasture species were used to monitor the available P pools in two alkaline clay soils.

In initial experiments with Cenchrus ciliaris (buffel grass), an apparent increase was noted in the size of the available P pool over a number of sequential harvests during a three month period. This apparent increase suggested P was being transferred from a previously unavailable pool to the available pool during the experimental period. Planting buffel grass after various periods of incubation of ^{32}P with soils established that the apparent increase also occurred in the absence of plants. This indicated that the increase was not driven by P removal from the soil by growing plants. It may represent a natural cycling of P that is occurring continuously in the soils.

A further experiment was run to determine whether species that differ in their efficiency to use soil P may influence this rate of transfer. The tropical legumes Stylosanthes hamata, Stylosanthes guianensis, Macroptilium atropurpureum, and Desmodium intortum were used in addition to buffel grass. Measurements of the initial size of the available P pools were similar with all species. Furthermore, the apparent rate of increase in the size of the available P pools was the same for all species in spite of large differences in both the rates of P removal and the total amounts of P removed by the various species. Differences between these species in their efficiency to take up and use soil P were therefore due to differences in their ability to exploit the same pool of available P. They were not due to a capacity of any of the species to expand this pool during their growing period by increasing the rate of transfer of P from previously unavailable sources. One soil had 212 μg/g of total P, of which 36 μg/g was available initially and 55 μg/g appeared to be available after 150 days. Figures for the other soil were 138, 19, and 25 μg/g respectively. Unlike previously published experiments using similar techniques to assess the availability of soil P, the apparent increase in the size of the available P pool was not linearly related to the amount of P removed from these soils. However, it was linearly related to time.

Key words: phosphorus, isotopic, dilution, tropical pastures, buffel grass, Stylosanthes, Desmodium, siratro.

3-1-5 Effect of Various Forms of Mineral Fertilizers on Grass Stand Productivity

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In field experiments (1975-1979) in the central region of Nonchernozem zone of the USSR the efficiency of liquid ammonia (82.3% N), plav (liquid nitrogen fertilizer containing 30% N), liquid complex fertilizer (10% N, 34-37% P_2O_5), ammonium polyphosphate (16%N, 61% P_2O_5), urea polyphosphate (17% N, 52% P_2O_5) and potassium metaphosphate (58% P_2O_5, 38% K_2O) was studied on grass swards which were grazed or cut 3 times. The aim was to determine the optimum rates and combinations of various forms of fertilizers and to determine conditions of their effective use. The dominating species in sward were cocksfoot (Dactylis glomerata L.), meadow fescue (Festuca pratensis Hud) and timothy (Phleum pratense L.).

Dry matter (DM) yields, with the $N_{240}P_{60-90}K_{120}$ rate, when using liquid ammonia, were 9.0 and 11.1 tons per hectare (t/ha); plav, 9.7 and 11.4 t/ha; ammonium nitrate, 9.3 and 11.3 t/ha under grazing and cutting, respectively (LSD_{05}=0.76 and 0.41 t). Liquid complex fertilizer (LCF) and ammonium polyphosphate gave the same dry matter yield increase as superphosphate. With $N_{30}P_{102}K_{180}$, average dry matter yields on pasture fertilized by LCF was 5.5 t/ha and with the $N_{240}P_{102}K_{180}$ rate, 9.7 and 9.9 t/ha respectively. Cutting gave similar results; with the $N_{240}P_{102}K_{120}$ rate of application, LCF yields were 11.3, ammonium polyphosphate, 11.3 and superphosphate, 11.0 t/ha.

Various forms of nitrogen fertilizers applied in combination with poly- and metaphosphates gave similar grass productivity in all treatments. Significant reductions in dry matter yields were observed when using combinations of urea and potassium metaphosphate. The use of liquid ammonia and potassium metaphosphate combination was of certain economical advantage as the annual NPK rate may be applied in one application, in spring or in fall.

Nitrogen fertilizers varied slightly in their effect on crude protein content of DM. With the N_{240} rate using liquid ammonia, crude protein contents of forages were 21.7 and 17.8%, grazing and cutting, respectively; plav, 20.3 and 16.1%; urea, 19.6 and 15.6%; and ammonium nitrate, 20.5 and 15.6%. Combined application of liquid ammonia or plav with potassium metaphosphate resulted in increased protein nitrogen and watersoluble carbohydrates and reduced nonprotein nitrogen. No significant effects of nitrogen fertilizers on grass mineral content were observed. Phosphorus content in DM of grass sward under 3-cut usage and application of 68 kg superphosphate was 0.28%; 102 kg, 0.37%; LCF, 0.29, 0.37, 0.39%; 136 kg, 0.37%; ammonium polyphosphate, 0.26, 0.37, and 0.38%, respectively. Combined application of liquid ammonia and potassium metaphosphate created most favorable conditions for agronomically valuable microorganisms.

Key words: nitrogen source, application rate, potassium, phosphorus, grass yield, grass composition.

3-2-1 Faecal Matter Decomposition Efficiency of Grazers and Browsers in Tropical Grazinglands

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Decomposition efficiency of faecal matter of various consumers is not directly related to any factors. It may vary according to type of consumer and conditions which are provided during the decomposition period. Our objective was to determine the efficiency of decomposition of faeces of grazers (e.g., cattle) and browsers (e.g., goat and rabbit) in field laboratory conditions.

Based on the field and laboratory experiments, the rate of faecal matter decomposition of cattle dung pats, faeces of goat and rabbit was determined. Decomposition rate in field conditions was determined by the "litt bag technique," while in laboratory conditions it was determined by following the procedure of SR Kathleen Angel C.D.P. and D.T. Wicklow (1974).

Much difference occurred in faecal decomposition rates in field and laboratory conditions. The maximum weight was observed in case of rabbits in field conditions, i.e., 64.8% in contrast to 50% in laboratory conditions. In case of goat and cattle dung pats the weight loss was 56.36%, 49.09% and 51.3%, 45.6% in field and laboratory conditions, respectively.

It is clear from results that under the same conditions of temperature and moisture, the order of faecal matter decomposition efficiency was in the following sequence: rabbit < goat < cattle, or 64.8%, 56.36% and 51.3% weight loss, respectively.

Decomposition of faecal matter plays a significant role in cycling of organic matter and nutrients in grazingland ecosystems, or in other words, decomposition efficiency is an important function in maintaining the soil fertility of the grazinglands.

Key words: faecal matter, decomposition efficiency, grazers, browsers, tropical grazinglands.

3-2-2 Manurial Value of Liquid, Anaerobically Digested Sewage Sludge on Grassland in the West of Scotland

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The manurial value of liquid, anaerobically-digested sewage sludge is under assessment in west Scotland to evaluate the effects of disposal on grassland. The concentrations of plant nutrients in sludges have been measured with sludge total-N being considered as two fractions: volatile-N and organic-N. The herbage yield response to sludge-N, relative to fertiliser-N, has been measured in a number of field trials evaluating the effects of sludge composition and season of application.

The concentration of organic-N, P and K in sludge depends on the DM concentration which was very variable (3-100 g kg^{-1}). Volatile-N concentration averaged 40-50% of the total-N content but was largely independent of sludge DM concentration. Relative yield response to sludge-N at the first harvest after application was, on average, equal to the volatile-N content but varied with season of application and DM concentration in the sludge. Late winter and late summer applications gave the best yield response to sludge-N relative to fertiliser-N. This is possibly explainable in terms of seasonal rainfall pattern, with rainfall increasing the relative response to sludge-N. Residual response to sludge-N during the season of application was equivalent to about 20% of the sludge organic-N.

This basic information on the manurial value of digested sludge and the results of the ongoing work will eventually be used to optimise the benefits of its disposal on agricultural land in Scotland.

Key words: manurial value, nitrogen, sewage sludge, grassland.

3-2-3

Utilisation of Animal Wastes for Grass Production

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Animal wastes contain considerable quantities of plant nutrients and if properly managed can be a valuable asset for maintaining soil fertility. A high proportion of wastes are spread on grassland and this presents special problems of contaminating the grass, low efficiency of the nitrogen and possible spread of disease. The objective of this experiment was to compare cattle slurry and pig slurry with chemical fertiliser for the production of grass silage and the liveweight gain of animals fed on the three silages.

There were 30 plots of 0.4 ha each in the experiment, 10 for each treatment. Slurry at 45 t/ha was spread 7 weeks before each of two silage cuts in the 3 years 1976 to 1978. The silages were fed to three groups of beef animals. It was found that cattle slurry gave the lowest yield and fertiliser gave the highest. The plant nutrient content of the grasses was influenced by the slurry treatment.

Soil analyses showed that cattle slurry increased the potassium status and pig slurry increased the phosphorus status of the soil.

Cattle fed on silage from the cattle slurry treatment had a significantly lower liveweight gain than the animals on the fertiliser treatment. The pig slurry treatment gave intermediate gains.

It can be concluded from the results that cattle and pig slurry are valuable sources of phosphorus and potassium. The nitrogen efficiency of the manure is low, particularly cattle slurry. The silage from the slurry treatments gave lower animal liveweight gain than the fertiliser treatment. This emphasises the need for care when using slurry on silage land.

Key words: animal wastes, grass production, fertility value, silage, animal performance, manure, slurry.

3-2-4 Influence of Liquid Manure Fertilization on the Amino Acids Composition and Magnesium and Potassium Content in a Meadow Grass Cultivated on a Carbonate Soil

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Meadows located on carbonate soils cover more than 7000 ha in the Szczecin Region. It is very important from practical point of view to learn about the influence of liquid manure on the feeding value of the meadow grass.

In 1976-1978, the field experiment on the carbonate soil was conducted. The following amounts of liquid manure per year were used: 1/control - without fertilizing, 2/liquid manure in doses of 30 m^3/ha, 3/60 m^3/ha, 4/90 m^3/ha, 5/120 m^3/ha. Liquid manure was applied in early spring and after every cutting during the vegetation period. Doses of liquid manure were divided into 4 parts. Magnesium (Mg) and potassium (K) content was estimated by atomic absorption method, nitrogen (N) by Kjeldahl method and amino acids composition by Amino Acid Analyser model AAA-881.

Analysis of the floral composition of the meadow grass showed the presence of the following species: Dactylis glomerata L. 41.5%, Phleum pratense L. 8.3%, Festuca rubra L. 10.6%, Arrhenatherum elatius L. P. B. 7.4%, Poa pratensis L. 7.2%, Festuca pratensis Huds. 5.1%, Alopecurus pratensis L. 4.3%, Familae diversae 15.6%.

Aspartic acid, glutamic acid, proline and leucine were found as predominant components of the grass protein. In much less quantity occurred such amino acids like serine, isoleucine, threonine, and methionine. Cysteine appeared only as a trace constituent of the assigned meadow grass. Both of these groups of amino acids were present in each of the tested grass cuttings. The estimated patterns of the grass contained the following exogenous amino acids: leucine, isoleucine, methionine, cysteine, threonine, lysine, and phenyloalanine.

Mg content at each dose of liquid manure was far below the level of 0.18-0.24% that is commonly considered as indispensable in the feedstuff from the meadow. The amount of Mg in the grass samples of this experiment ranged from 0.03% to 0.11% of dry matter. The highest level of Mg (0.15% Mg) was obtained from the treatment not fertilized with liquid manure.

Application of liquid manure at different rates did not affect the content of the individual amino acids in the meadow grass. Mg level in dry matter of plants was lower in comparison to the commonly accepted standard for the feeding stuff from the meadow. In reverse to Mg, increasing doses of liquid manure enhanced the concentration of K in the grass.

Key words: liquid manure fertilization, meadow grass, amino acids, magnesium, and potassium content.

3-2-5 Waste Water Application, Dry Matter Production and Nitrogen Balance of Rhodes Grass Grown on Fine-Textured Soil or on Sand Dunes

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The shortage of irrigation water in the semi-arid zone of Israel necessitates the use of partially treated municipal effluents for irrigation of forage grasses. Irrigation with sewage effluents is being considered very carefully, ecologically, and intensive research is being carried out to contribute to both maximizing production and minimizing the pollution hazard.

A high nitrogen input originating from intensive application of effluent water may well increase the dry matter production of forage grasses but this also increases the pollution hazard. Frequent application of relatively small quantities of effluent water was suggested as an efficient method for improving N uptake by Rhodes grass (Chloris gayana Kunth.) swards. It was expected that nitrate pollution would be reduced and nitrogen fertilization could be saved.

Field experiments of five and two years duration were conducted with Rhodes grass grown on a fine-textured soil (Grumusol) and on a sand dune soil, respectively. The grass was sprinkle-irrigated. Treatments were different frequencies of irrigation using three sources of water in combination with four levels of N fertilization.

Irrigation according to 100% class A pan evaporation (approximately 1000mm) revealed the superiority of twice-a-week application of effluents on fine soil. This resulted in high yields and high N recovery as well as no response to additional N fertilization. Differences between irrigation frequencies diminished as N input increased and effluent application was reduced to 80% of class A pan evaporation. Total N input higher than 660 and 380 kg/ha did not increase dry matter production on fine and sand dune soils, respectively, but did increase N losses. Dry matter production and N-balance values are discussed in relation to quantity and frequency of water application and N loss due to denitrification or leaching.

The low nitrate level found below the shallow root system of Rhodes grass together with conditions favoring denitrification in the fine soil atmosphere, revealed that the hazard of nitrate pollution is low. Under sand dune conditions the potential for nitrate pollution is much higher due to leaching.

160 and 250 kg of fertilizer-N/ha supplementing effluent water containing 50 and 20 ppm N are required for achieving optimal and comparable Rhodes grass yields from fine soil and sand dune swards.

If effluent water is recognized as a nutrient solution and not just as a source of water which has to be disposed of, then efficient use of this resource will bring about a considerable saving in the cost of N-fertilizer.

Key words: Rhodes grass, Chloris gayana Kunth., waste water, nitrogen, yield, pollution hazard.

3-3-1 On Interactions of Anions Taken Up by Alfalfa and Orchardgrass in Pot Culture and in Water Culture

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Excessive absorption of nitrate in legumes and grass causes nitrite poisoning of dairy cattle. This study was conducted to study the interactions of anions (NO_3^-, Cl^-, $H_2PO_4^-$, SO_4^{2-}, SiO_3^{2-}) taken up by alfalfa (Medicago sativa L.) and orchardgrass (Dactylis glomerata L.)

In pot culture method alfalfa (Du Puits) and orchardgrass (Kitamidori) were sown in a polyethlyen pot (12 cm by 12 cm deep with 4 small drainage holes in bottom) containing a 4:1 mixture of Noppero clay loam soil and sand.

The soil mixture contained 12.4mg/100g dry soil of available P_2O_5, 40mg/100g dry soil of exchangeable K_2O and had a pH of 6.5 with H_2O.

Nitrate-nitrogen (NO_3-N) levels with KNO_3 were 50, 150 and 450mg/pot, and silicate (SiO_3^{2-}) levels with silicagel of 100 mesh for chromatography were 0.4, 0.8 and 1.6g/pot. Each pot was placed in a growth chamber at 27°C during the day and 21°C at night, and all pots were watered with demineralized water as needed.

In the water culture method, seedlings of alfalfa and orchardgrass were grown in the tray with the previous 4:1 soil mixture, for 30 days in greenhouse. The seedlings were planted pots with the water culture solution. Nitrate-nitrogen (NO_3-N) levels with KNO_3 of the solution were 3, 9, 15 meq./l and Cl^-, $H_2PO_4^-$, SO_4^{2-} were 1, 3, 9, meq./l, respectively.

Those plants were harvested and the anions (NO_3^-, Cl^-, $H_2PO_4^-$, SO_4^{2-}, SiO_3^{2-}) were analyzed. Four replications of each treatment were prepared and the plant samples were made after tissues had been ground to 40 mesh size.

Nitrate concentration was increased with the rising of nitrate level and was greater in orchardgrass than in alfalfa tissues. The NO_3^- x Cl^- competition was found for leaves of both orchardgrass in water and in pot culture; the Cl increase in leaves of orchardgrass decreased its NO_3^- uptake. Also NO_3^- x $H_2PO_4^-$ competition was similar to NO_3^- x Cl^-, but no statistical significance was found for the NO_3^- x SO_4^{2-} interaction. NO_3^- x SiO_3^{2-} and NO_3^- x $H_2PO_4^-$ interaction was found in leave of orchardgrass grown pot culture, the correlation cofficient r being -0.716 and -0.647, respectively.

In conclusion, there is interaction in grass. Nitrate, chlorine, phosporous, and silicate, except sulphate, uptaken in leaves of orchardgrass, competed reciprocally.

Key words: interaction of anions, alfalfa (Medicago sativa L.), orchardgrass (Dactylis glomerata L.), water culture, pots culture, nitrate.

3-3-2 Effect of Converting Chaparral to Grassland on Soil Fertility in a Mediterranean-type Climate

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In the region of Mediterranean-type climate in California, brush is converted to grassland to reduce fire hazards, increase feed for herbivores, and increase water yields. There is little information on how this change of cover type affects soil fertility over a long-term period. Research was initiated to measure the long-term effect of converting brush to grass on the availability of nutrients in the soil.

In 1956 chaparral growing on Los Gatos soil (fine-loamy, mixed mesic family of typic argixerolls) was crushed, burned, seeded to grasses and clovers, and half the area was fenced to exclude herbivores. Sprouting brush was either treated periodically by burning, or with herbicides or was not treated at all. Twenty-three years after the initial burn, about three percent of the cover on reburned plots was brush, virtually none was brush where herbicides were used, and nearly 100% was brush where nothing was done to control regrowth. Herbaceous plants were abundant where brush sprouts had been controlled. Soil samples were taken from the six treatments for chemical analysis and a pot experiment. Soft chess (*Bromus mollis* L.) was grown in pots fertilized with all combinations of N, P, and S. The plants were analyzed for N, P, K, S, Ca, and Mg.

In the pot study uptake of N, P, K, S, Ca, and Mg was greater from soils where brush regrowth was controlled than from soils where brush had regrown. These differences were much greater for soils under grazing. Extractable nutrients in the soils from the grazed area were also higher from grassland plots than from brush plots.

The grazed grasslands had 81% ground cover by living plants, of which 14% was annual legumes, 25% annual grasses, 30% *Erodium* spp., and 11% perennial grasses. The ungrazed plots had 25% ground cover, and only 3% legumes, 7% annual grasses, 1% *Erodium* spp., and 9% perennial grasses.

Nutrient availability was greater after a 23-year period in a brush-soil converted to grassland than where brush regrew, and this difference in soil fertility was enhanced by grazing. The difference in soil fertility on the grazed grassland plots may be due to: 1) the shallower, more fibrous root systems of grassland species (as compared to brush) resulting in a retention of mineral nutrients in the surface soil; 2) increased rate of cycling, and thus nutrient availability, due to the grazing animals; 3) the contribution of annual legumes to soil N; and 4) a reduction in surface soil erosion, there being much bare soil and an erosion pavement under the brush.

Key words: annual grasslands, extractable soil inorganic-N, P, K, S, Ca, and Mg.

3-3-3 Effect of NPK Fertilization on Mineral Composition of *Poa pratensis* L. Grown on a Shallow Muck Soil

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More than a million hectares of muck soil which is suitable for agriculture exists in the northern portion of the cornbelt in the USA. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merrill) are the major grain crops grown on these soils.

Because of the problems associated with producing grain crops, e.g., wet conditions, early frosts and excessive weed competition, many farmers are using these muck soils for pasture. Since very little information is available relative to the fertility requirements of these pastures, the following two-year study was initiated in the spring of 1979 on Edwards muck soil (Limnic Medisaprist) on the Pinney-Purdue Agricultural Center at Wanatah in northwestern Indiana. Eight combinations of N-P-K fertilizer were applied with three replications to a permanent Kentucky bluegrass (*Poa pratensis* L.) pasture. Dry matter yield, percent crude protein, and mineral composition were determined for each of four cuttings taken throughout the 1979 and 1980 growing seasons. The harvested forage was from a 1.5 m^2 cage randomly located in each replication.

Application of N fertilizer had a pronounced effect on dry matter yield and crude protein production over the two-year period while P and K had little, if any, effect on dry matter yield or crude protein production. The application of 168 kg/ha of N increased dry matter yield of Kentucky bluegrass from 6.3 to 8.2 mt/ha in 1979 and from 6.4 to 7.8 mt/ha in 1980. Crude protein production was increased from 1153 to 1983 kg/ha in 1979 and from 1206 to 1974 kg/ha in 1980.

Nitrogen significantly increased N concentration in plants, especially during the earlier part of the growing season. A slight increase in P concentration resulted from the application of P fertilizer although adequate levels of P were present in control forages. Potassium levels in the plants increased with application of K fertilizer. However, K levels were adequate in plant tissue from the unfertilized treatment.

Although P appeared to be adequate, the application of P with N significantly increased the concentration of N over that of N fertilizer alone. The addition of N fertilizer resulted in a small, but highly significant, increase in K concentration. Nitrogen fertilization also increased the concentration of Ca and Mg in Kentucky bluegrass forage while concentrations of Ca and Mg were significantly reduced by the application of K fertilizer.

Key words: NPK fertilization, *Poa pratensis* L., Kentucky bluegrass, mineral concentration of N, P, K, Ca, Mg, muck soil, permanent pasture.

3-3-4 Some Effects of Applied Nitrogen on Grass Growth in Field Swards at Different Times of Year

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Results from 21 field experiments are brought together to study the effects of level of applied nitrogen (N) on (a) the regrowth of grass over 8 weeks following a cut and (b) the situation after about 6 weeks' regrowth, at different times of year.

(a) Percent N and nitrate-N in herbage generally increased in the early stages of regrowth and then declined. The better the growing conditions, the faster was the rate of decline. The positive effect of applied N on relative growth rate tended to be greatest and most short-lived when growing conditions were most favourable.

(b) Response to applied N increased as growing conditions improved in the spring in respect of yields, numbers of tillers and leaf size and declined as growing conditions deteriorated in the autumn except in respect of number of tillers. Area per green leaf blade tended to be greatest in September and response to N was large at this time. Response to the final increment of N was very low in the autumn after September in respect of area per blade and yield of blade.

The study contributes to a better understanding of the effects of applied N on grass growth at different times of year and hence to more efficient management.

Key words: nitrogen application, time of year, dry-matter yield, nitrogen yield, nitrate-N, tillers, leaves, 'stem'.

3-4-1 Effect of Lime on Lucerne in Relation to Soil Acidity Factors

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Most soils in north-eastern Victoria are acid and problems commonly occur with lucerne (Medicago sativa) establishment and production. Aluminium and manganese have been recognised as major components of soil acidity. Liming to reduce exchangeable aluminium (AL) has been suggested as a rational approach to determining the lime requirements of lucerne growing in acid soils.

This study was undertaken to clarify the relationship between soil acidity factors and lucerne growth and to provide a basis for liming recommendations in north-eastern Victoria. The aim was to determine the effect of a range of rates of lime on (i) establishment, production and nutrient status of lucerne c.v. Hunter River and (ii) to relate these parameters to changes in pH, AL and available manganese (MN) in the top (0-15cm) and sub-soils.

Three field experiments were established on the acid granitic soils of the Strathbogie Ranges, where average rainfall is approximately 900mm, with the major incidence in winter-spring. Each experiment was a replicated split plot design with three main plots of ground agricultural limestone (80% $CaCO_3$), drilled with the seed and six sub-plots of broadcast agricultural limestone applied and incorporated two months prior to sowing.

Average annual lucerne production over three years ranged from 1.1 to 6.5t ha^{-1} on the unlimed plots and from 5.1 to 9.8t ha^{-1} on the plots limed at the heaviest rate.

In the top soil AL was virtually eliminated by the highest rate of lime application, but was largely unaffected in the sub-soils. At the site where AL in the sub-soil was higher than 1.0 meq./100g, lucerne production was considerably lower than at the other sites.

Levels of MN were reduced in the top soil by lime; however, lucerne seedlings at all sites showed symptoms of severe manganese toxicity. The severity of the symptoms decreased with increasing rates of application of lime. In any treatment levels of manganese in mature lucerne varied throughout the year, but were reduced by lime additions.

In this series of experiments, the determination of AL alone in the top soil was not sufficient to determine the lime requirements of lucerne. In these soils manganese toxicity occurred in seedling and mature lucerne when AL in the top soil had been eliminated. Reductions in lucerne yield also occurred as a result of high levels of AL in the sub-soil which were not affected by surface applications of lime.

Lucerne yield was highly correlated with AL in the top and sub-soil and MN in the top soil. pH in the top and sub-soil was rejected as a significant contributor to yield in the stepwise regression model used to analyse this data.

Key words: lucerne, Medicago sativa c.v. Hunter River, soil acidity, exchangeable aluminium, available manganese, pH.

3-4-2

Liming for Tropical Legume Establishment and Production

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Liming has been declared unnecessary for tropical legume production because 1) tropical legumes are efficient in extracting Ca from soils and are tolerant of excess Al, Fe and Mn, and 2) they are readily nodulated by alkali producing Rhizobium which can function in acid soils. Numerous research reports from Australia, Uganda, Brazil and Colombia lend credence to this thinking, since no lime responses were observed in these studies. In other work, liming actually depressed tropical legume growth. However, positive responses have been reported in Australia, Hawaii and Brazil. In Florida, we have observed considerable improvement in the production of Siratro (Macroptilium atropurpureum Urb.), Desmodium heterocarpon DC., Stylosanthes guianensis Swartz, Centrosema pubescens Benth. and Aeschynomeno americana L. with increasing lime rates up to 2000-3000 kg/ha in pot studies, research plot studies, and/or in commercial pastures.

Perhaps tropical legume production could be increased in other regions through a combination of liming, correcting nutrient deficiencies, and innoculating with Rhizobium adapted to moderate soil pH. At least there now is sufficient evidence to suggest that lime responses should be evaluated when tropical legumes are being introduced into new areas.

Key words: liming, lime,tropical legumes, soil pH.

3-4-3

The Effect of Nitrogen Level and Defoliation Interval on the Productivity and Protein Content of Five Introduced Grasses

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An experiment was conducted at Bogor Agricultural University form August 1976 to December 1977 to study the influence of N fertilizer level and cutting interval on the yield and protein content of tropical grasses.

The experiment was conducted on a latosol soil with medium fertility, 260 m above sea level with 4230 mm annual rainfall laid out in a split-split plot design with three replicates. There were 5 forage species, 5 nitrogen fertilizer levels, and 3 cutting intervals. Forage species, fertilizer levels, and cutting intervals were treated as main plot, sub-plot and sub-sub plot variables, respectively. The forage species were Brachiaria decumbens Stapf., Brachiaria ruziziensis Germain et Evrard, Digitaria decumbens Stent., Pennisetum purpureum Schum. and Setaria sphacelata (Schumach.) Stapf and Hubbard. Except Pennisetum purpureum the grass species were relatively new introductions.

The nitrogen levels were 0, 100, 200, 300 and 400 kg/ha, annually. Urea was used as the nitrogen source. Phosphate and potassium were added to the whole plots at the rate of 150 kg P_2O_5/ha and 150 kg K_2O/ha, annually. The cutting intervals were 30, 40 and 60 days. The urea application was divided according to cutting intervals, and applied after each cutting. Cutting height was 15 cm above ground level. Lime was applied to attain a soil pH of 6.5.

1. The grass species significantly ($P<0.01$) influenced the dry matter yield. The ranking was as follows: Pennisetum purpureum 12.40 tons; Digitaria decumbens 10.00 tons; Brachiaria decumbens 10.03 tons; Setaria sphacelata 8.20 tons; and Brachiaria ruziziensis 7.09 tons/ha, annually.
2. Nitrogen application improved the dry matter yield. The application of 300 kg N/ha/year resulted in the highest dry matter yield while no added nitrogen resulted in the lowest.
3. Cutting interval significantly ($P<0.01$) influenced the dry matter yield. The highest and the lowest dry matter yield came from the 40 day and 60 day cutting interval, respectively.
4. The influence of grass species on the crude protein yield was not significant.
5. Fertilizer application affected the crude protein yield. The level of 300 kg N/ha/year resulted in the highest crude protein yield (86.68 kg/ha/year), and no fertilizer application produced the lowest crude protein yield (45.56 kg/ha/year).
6. Cutting intervals significantly ($P<0.01$) influenced the crude protein yield. The longer the cutting interval the lower the crude protein yield.
7. The best N fertilizer level was 300 kg per ha annually.
8. The best cutting interval was 30 days.
9. There were no interactions among the three treatments, i.e. grass species, nitrogen levels, and cutting interval.

Key words: Brachiaria decumbens, Brachiaria ruziziensis, Digitaria decumbens, Pennisetum purpureum, Setaria sphacelata, nitrogen, cutting interval, yield.

3-4-4 Performance of Several Grass Species Under Phosphorus Stress Conditions

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It might be said that phosphorus condition of grassland soils in Japan has not been enough to support the better establishment and/or growth of forages, because grassland soils are mostly derived from volcanic or alluvial materials, which are commonly very poor in phosphorus.

Therefore, it should be very important to study how to manage grasses for their establishment and growth on soils having a high phosphorus fixation capacity and/or low phosphorus availability.

The selection of grasses to be introduced onto such soils should be very important for supporting their better establishment and growth under phosphorus stress conditions.

Experiments had been carried out to study the phosphorus uptake abilities of several forages (*Digitalia adscendens*, *Chloris guyana*, *Paspalum notatum*, *Sorghum bicolor* x *S. sudanese*, *Zea mays*, *Lolium multiflorum*, *Trifolium repens*, *Medicago stativa*, and others), the utilization efficiencies of phosphorus for their growth under phosphorus stress conditions, the competition of their growth in relating with their phosphorus uptake from the limited soil phosphorus, and the kinetics of phosphorus uptake from cultural solution by their excised roots.

Results obtained were as follows:

1) Relative growth rates (growth rate with low phosphorus supply/growth rate with optimum phosphorus supply) were closely correlated with their phosphorus uptake rates. Relative growth rate was higher in the following order: *Digitalia* > *Paspalum* > *Chloris* > *Sorghum* x *S.* > *Zea mays*.

2) When the forages were sown on a soil whose phosphorus availability was limited, their differences in phosphorus uptake rates determined their growth competition. As an example, growth competition among *Sorghum*, *Zea*, and *Digitalia* had depended on their phosphorus uptake capacities under phosphorus stress and their competition was more severely amplified with low soil moisture status. That is, under the phosphorus stress and the low soil moisture, *Digitalia*, which had a higher phosphorus uptake potential, more severely suppressed the growth of other forages having less phosphorus uptake potential.

3) The results of kinetic analysis on phosphorus uptake by the excised roots gave reliable information on their phosphorus uptake potential and growth competition under the phosphorus stress condition.

From the kinetic analysis, the phosphorus uptake potential of excised roots was higher as ranked as follows: *Digitalia* > *Paspalum* > *Lolium* > *Sorghum* x *S.* > *Trifolium* > *Zea* > *Medicago*.

Key words: phosphorus stress, phosphorus uptake, *Digitalia adscendens*, *Paspalum notatum*, *Chloris guyana*, *Sorghum bicolor* x *S. sudanese*, *Lolium multiflorum*, *Zea mays*.

3-4-5 Effect of Liming Pasture on Milk production and Animal Health and on Growth and Composition of Pastures

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An unreplicated experiment, involving a split dairy farm, was conducted over a three-year period at Lardner, Victoria, to assess the effect of topdressing pastures with lime on milk production and animal health, as well as on the dry-matter yield, botanical composition and mineral content of the pastures.

Each paddock on the 92-hectare property was divided into two to give as near as possible two identical 46-hectare farmlets, one of which was topdressed with a single application of lime (90% calcium carbonate, 3.8 tonne/hectare) at the start of the experiment. The other farmlet was left untreated. The 110-cow herd was also divided into two identical herds, on the combined basis of milk production, breed, age, and calving date. One herd was allocated to the limed farmlet, the other to the unlimed farmlet, and the two herds were milked separately so that milk production from each farmlet could be recorded.

The two farmlets were farmed by the same operators, and otherwise treated identically in terms of fertilizer treatment, pasture and herd management. Almost no concentrates were fed to stock. All pastures (mainly perennial ryegrass and white clover) on the two farmlets received an adequate annual maintenance topdressing of superphosphate and potash (muriate) as well as an initial application of molybdenum.

Records were kept over a four-year period (including a one year settling-in period before lime was applied) of daily whole milk and butterfat yield, monthly liveweight of individual cows, animal health problems, pasture dry matter yield and botanical composition, herbage mineral content, changes in soil pH, available potassium (K) and available phosphorus (P).

The two herds produced similarly during the pre-lime lactation.

During the three-year experimental period following lime application, lime had no measurable effect on whole milk or butterfat production, the incidence of animal health problems (including mastitis, mineral deficiencies, bloat, metabolic and other diseases), pasture dry matter yield and botanical composition.

Lime increased the calcium content of the herbage, but had no significant effect on potassium or magnesium levels.

We concluded that in the particular area under study, there was no economic benefit to be obtained by topdressing existing pastures with lime on this soil type where pH ranged from 5.3 to 5.6.

Key words: lime, milk production, animal health, pasture production, botanical composition, mineral content.

3-5-1

Predicting Yield Response to Nitrogen Fertilization on Northern Great Plains Rangelands

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Nitrogen (N) deficiencies limit plant growth on most rangelands of the northern Great Plains. Yet, despite a demonstrated potential to significantly increase forage production, range fertilization is not a common practice. Range forage is a low per unit area income product, and the vagaries of climate, plus fluctuating fertilizer costs and livestock values, make range fertilization a risky investment of capital. Our objectives were to develop yield predicting equations based on climatic, site, and N-rate variables that would enhance range fertilization decisions and reduce financial risks.

A data base was developed from range fertilization research results in the northern Great Plains. It represented five distinct range sites. Stepwise regression analyses were used to develop yield-predicting equations for both fertilized and nonfertilized range (r^2 = 0.83; n = 194 and r^2 = 0.88; n = 51, respectively). Independent variables included combinations of monthly precipitation and average site yield for nonfertilized range. For fertilized range, additional variables representing N-rate, an N-sink effect, and N-rate by precipitation interactions were included. Average site yield provided an effective means of accounting for the wide range of inherent productivity among range sites.

The results of this research indicated that, in the northern Great Plains, yield response of native range to N fertilization can be reliably predicted using readily obtainable climatic and site data. These predictive equations can enhance fertilization recommendations and lessen financial risks, especially as they are used in simulation models to evaluate fertilization practices on individual ranches, taking into account the total ranch operation.

Key words: range fertilization, yield prediction, rangeland, nitrogen

3-5-2 Comparisons of Urea and Calcium Ammonium Nitrate on Grassland in Ireland

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The objective of these studies was to evaluate urea as a source of nitrogen for grassland. Urea was compared with calcium ammonium nitrate in a number of field trials. There were three series of trials, namely (a) the production of grass early in springtime where nitrogen was applied at 0, 30, 60 and 90 kg/ha in late January or early February in the years 1978 and 1979; (b) the production of grass for silage early in the season (May) where the nitrogen was applied at 0, 60, 90, 120 and 150 kg/ha in late March or early April in the years 1976-77-78 and 1979; and (c) the production of grass for silage in summer (August) where the nitrogen was applied at 0, 60, 90, 120, 150 kg/ha in June or July in the years 1978 and 1979. The trials were conducted in different locations throughout the country. All plots were harvested by machine and yields were measured in terms of dry matter.

The application of nitrogen for the production of grass early in springtime increased the yield in both years. There was no difference in yield between the plots receiving nitrogen in the form of urea and those receiving nitrogen in the form of calcium ammonium nitrate. There was no difference between the two sources of nitrogen for the production of grass for silage early in the season for three years. In one year, 1979, at the 90 kg of nitrogen level there was an increase of 11 percent in dry matter yield when nitrogen was applied as calcium ammonium nitrate. For the production of grass for silage in summer the yields were lower from the urea source of nitrogen at most levels of application in both years.

Reports in the literature have indicated that urea may not be as efficient a source of nitrogen for grassland as calcium ammonium nitrate. Under Irish conditions it can be concluded that urea as a source of nitrogen is as efficient as calcium ammonium nitrate when applied for early grass production in springtime and for the production of grass for silage in May. On the other hand, for the production of grass for silage in summer urea as a source of nitrogen was less efficient than calcium ammonium nitrate.

Key words: nitrogen level, urea, calcium ammonium nitrate, grass yield.

3-5-3 Two Years' Residual Effects from Very High Nitrogen Applications on Clay Soil Under Grass in a Humid Temperate Climate

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In recent field trials on all-grass swards on clay soils fertilizer rates of 480 kg per ha and over showed distinct residual effects in the following year. This paper analyses the considerable residual effects of one treatment on heavy clay soil over two experimental years, after very high rates of N had been applied during three pretreatment years (totalling 800 kg N or more per ha per year). The residual effect was measured through the increase in yield over a reference treatment, at one rate of N application (40 kg N per ha for each cut, totalling 200 and 240 kg N per ha in the first and second experimental year, respectively).

Over the three pretreatment years the amount of N applied exceeded the amount of N harvested by 941 kg N per ha. The excess N was reflected in accumulation of mineral N in the soil.

At the beginning of the first experimental year the soil contained 314 kg mineral N per ha against the reference treatment 21 kg N. The accumulated mineral N was nearly depleted by the end of the first season. A residual effect was evident at every cut, and over the whole growing season the increase in yield was 6 t DM and 199 kg N per ha.

In the second experimental year there was no difference in soil mineral N status of the treatments. Still, a residual effect was observed through an increase in yield of 1.1 t DM and 21 kg N per ha.

The study showed that on heavy clay soils - despite N losses from the soil, especially through leaching in winter - part of the applied N may remain in the soil-plant ecosystem and will be available for grass growth in the following season(s).

Key words: grassland, nitrogen fertilization, residual nitrogen, soil mineral nitrogen, yield, nitrogen uptake.

3-5-4 Influence of Cover Crops Upon the Development of Undersowing Clover and Alfalfa

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In field experiments carried out in 1976-1979 on the brown soil in the beet-growing region the effectiveness of cover crops harvested in the milk ripeness (cereals) and green ripeness (horsebean) stage on the development of undersowing clovers was found. Horsebean, then oats and least barley brought down the percentage of radiation the most during the whole period of growth. But in the first half of the vegetation period the sequence of radiation intensity lowering by cover crops was opposite. The competition of cover crops and undersowed clovers for water became evident, especially in drier and warmer periods when soil moisture was increasing, in the sequence barley < oats < horsebean < clover that were sown without cover crops.

The complex influence of the cover crops on the underplanted crops was found by means of mass determination of underground and aboveground biomasses of clover crops - 1 m^2. The mass of undersown clovers decreased under the increase of cover crop sowing and with the extension of the overshadow period. The largest differences were found in the period of cover crop harvesting. Clovers that were sown into barley were kept down most and their mass was only 13-21%, oats 18-27%, horsebean 49-68% as compared with plants without the cover crops (100%). Red clover was more tolerant of the cover crop than alfalfa. After harvest of the cover crop the differences decreased in favorable years and increased in unfavorable ones.

Clovers sown without the cover crop gave yields less by 50-60% in the years of foundation than in the second year of vegetation and therefore it is not possible explicitly to recommend the way of foundation. Clovers sown into the grain-harvested cereals gave the lowest yields of fodder and nutrients in the second year of their vegetation. Higher yields and larger certainty of foundation of well-closed stands were found with decreasing of cover crop sowing on 1-2 million germinal seeds per ha and with hay-harvesting in the period of stooling till heading stages. Of the cereals, barley has highest tillering, and therefore is least suitable as a cover crop. Better results were reached with the clover undersowing into oats and spring wheat that were harvested at the green ripeness stage. The best cover crop was horsebean with normal seeding and harvesting at green ripeness stage. Horsebean had good residual effect on the growth of clover also in the second year of vegetaion.

Key words: clover crops, cover crops for forage, soil moisture content, light availability, development of clover crops.

3-5-5 Influence of N Fertilizer on a Pangola (*Digitaria decumbens*) Sward

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The effects of N fertilization (0 to 800 kg/ha/year), fractionated by cutting, on the DM yield, mineral composition (N, P, K, Ca, Mg and Na) in the plant and chemical changes in the soil (pH, Ca, Mg, Na and K) were studied in a pangola grass sward. Treatments were distributed in a randomized block design with four replications on a ferralitic soil with the following composition: pH, 3.6; OM, 3.0%; P, 2.0 ppm and 10.0, 0.19, 0.36 and 2.76 meq/100 g soil for Ca, Na, K and Mg, respectively. The experimental area was fertilized with 50 kg P and 100 kg K/ha/season and irrigated every 15 days with 50 mm of water during the lowest rainfall and temperature season. DM yields were adjusted by the quadratic equations $y = 2.51 + 0.005X - 0.00005X^2$ (rainy season) and $y = 2.3 + 0.03X - 0.00003X^2$ (dry season) where y = DM yields (t DM/ha) and X = kg N applied. Considering the seasonal effects on this species, the calculated N fertilizer input was 100 and 200 kg N/ha for the rainy and dry seasons, respectively to obtain approximately 7.4 t DM/ha. DM and CP were related to N in both seasons DM decreasing 0.02% and CP increasing 0.05% for each kg of N applied. N utilization efficiency (recovered or converted to DM) decreased sharply as N doses increased. Ca, Mg, Na, K and P percentages were related to N applications. Ca, Mg, and Na were ' 52, 0.12 and 0.62% and increased as N applied level was increased. On the other hand, P and K decreased (0.26 and 2.06%, respectively) as N increased. All soil indices significantly ($P<0.001$) diminished as N fertilization increased, and pH decreased from 0.21 to 1.8 units. There was a 50% decrease in Mg and K and a 20% decrease in Ca. Data from plants and soils suggest that intensive forage exp'oitation based on N fertilization can be limited by the high extraction rates of other elements and possibly by P deficiencies in grazing animals. Results suggest that 300 kg N/ha/year is the optimal level under Cuban conditions.

Key words: nitrogen fertilization, *Digitaria decumbens*, dry matter yield, chemical composition.

3-6-1 Impact of Phosphorus and Potassium Fertilization on Maintaining Alfalfa Sward on Hokkaido

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Several studies have been conducted on the introduction of adaptable cultivars of alfalfa under various environmental conditions in the Tokachi region located in the eastern part of Hokkaido. This area is one of the most important dairy zones in Japan. Grassland occupies about one half (536,000 ha, 1979) of total agricultural land. The acreage in 1979 of grassland in the Tokachi region is the largest and occupies 104,200 ha (forage legumes, 3,910 ha; forage grasses, 2,840 ha; mixture of legumes and grasses, 75,400 ha), representing 20% of the total grassland in Hokkaido. Though considered as the most desirable forage legume, alfalfa acreage in this region has not increased substantially.

Research studies were carried out under two environmental conditions: (1) an experiment at six dairy farms located on alluvial soil and diluvial soil of the Tokachi plains 100-200 m in elevation above sea level, (2) an experiment in the Tokachi highland at elevation of 500-700 m.

Dry matter yield varied in general with the harvest year, cultivar, management method, location, etc., however, yields were highest in the alluvial soil area where accumulated temperatures in total C. degrees exceeded 2,400 and where soil fertility was high. Lowest yields were associated with areas of lower temperature, higher elevation, more severe environmental conditions, foggy areas, and areas limited in sunshine duration.

Applications of N, P, K. Ca, and B as basic fertilizers, as well as a topdressing after the first harvest, were associated with productivity of alfalfa and higher percentages of alfalfa in mixtures with grasses. Particularly, the topdressing of K was fairly effective in obtaining a higher yield.

Proper fertilization resulted in a dry matter yield approaching 13 mt/ha at locations where favorable circumstances were taken advantage of by a number of dairy farmers.

Among six cultivars (Narragansett, Vernal, DuPuits, Italy, Grimm, Rhizoma), the first and the last made better growth than the others at the test fields of elevations of 424 m, 565 m, and 717 m above sea level; with accumulated rainfalls of 614 mm, 674 mm and 708 mm; and accumulated temperatures of 2,362°C, 2,364°C, and 2,128°C.

Key words: alfalfa (*Medicago sativa*, L.), Narragansett, Vernal, DuPuits, Grimm, Rhizoma, dry matter yield, environmental factors.

3-6-2 Suitability of Early Pleistocene Sandy Lowlands for the Cultivation of Alfalfa (Medicago sativa L.)

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The areas with sandy soils at the pleistocene lowland of the German Democratic Republic are ameliorated on a large scale. In these lowlands low bogs appear together with hydromorphic sandy soils. The latter are situated higher above the groundwater level. In consequence of the lowering of groundwater by amelioration being effective on a large scale, these sandy soils are no longer suitable for an intensive and high-yielding grass cultivation. Especially during the summer months the comparatively shallow-rooted grasses cannot meet their requirement from the groundwater. Therefore, it was to investigate whether and on what conditions higher and more reliable forage yields can be obtained on such soils by cultivation of the deeper rooted alfalfa (Medicago sativa L.).

In addition to cultivation experiments, the water consumption and the removal of macronutrients were determined in groundwater lysimeters. Several soil types were separated, which differ in substratum, content of calcium carbonate, C_t, and N_t, in pH value, degree of base saturation, and in the amplitude of groundwater. The groundwater level varies from 40 to 250 cm dependent on soil type and weather conditions. The relationships between these factors and the value of alfalfa for cultivation are proved quantitatively. The experiments have demonstrated that new seedings performed in spring were not able to use the groundwater in 70 or 100 cm of depth until the beginning or the end of June, respectively. As essential as a deeper groundwater level can be for old stands, so important is the water capacity in the top- and subsoil with new seedings. Medium groundwater levels of about 100 cm appear especially favorable. In the vegetation period higher groundwater levels are tolerated well. At the same water supply and same weather conditions the alfalfa stands evaporate high water quantities similar to those of the stands of cultivated grasses. At a groundwater level of 120 cm alfalfa took 20 to 70 per cent of the total water consumption from the groundwater according to weather conditions. 5 to 11 mm per day were evaporated from the groundwater at this level after an obviously vast utilization of the soilwater store in dry periods. In practice reasonable yields were obtained still at groundwater levels of 150 to 220 cm. According to the type of sandy soils annual yields of 6.0 to 8.5 t of drymatter per hectare were achieved on large areas.

Key words: hydromorphic sandy soils, soil characteristics, qualification for alfalfa, water consumption of alfalfa.

3-6-3 Influence of Nitrogen and Phosphorus Fertilizers on *Medicago sativa* L. in High Acidity Soils

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An investigation was carried out over an eight-year period near Troyan, at an altitude of 400 m, to determine N and P fertilizer influence on *Medicago sativa* L. in grey, high-acidity woodland soil. The aim was to establish N and P fertilizer influence on the growth, development and yield of alfalfa sown for fodder in non-irrigated foot-hill areas of Bulgaria.

In one experiment, N fertilizer was introduced in increasing amounts and with different P levels; in another, the annual N fertilizer amount was introduced fractionally; in a third, N and P fertilizers were introduced in combination with other fertilizers for the purpose of establishing their aggregate influence on alfalfa yield. The experiments were carried out under the block method, with six replications of experimental plots of 25 sq. m. each.

It was established that P fertilizer reduced alfalfa hardiness to unfavorable climatic conditions and to diseases, and increased the weed content in the stand itself and in the fodder obtained. P fertilizer enhanced alfalfa hardiness to low temperatures, to dry spells during vegetation, to diseases and to lodging. Applied by itself, P fertilizer increased the number of stems per sq. m. Plants reached their maximum height when combined N and P fertilizers were applied.

Applied by itself, N fertilizer increased fodder yield, but only when introduced at higher rates. When introduced fractionally, the annual fertilizer amount led to the same yield as in the control plot. As compared to N fertilizer, Mo fertilizer introduced with a P and K combination led to a higher fodder yield. In combination with P and K, N and Mo fertilizers were mutually complementary, and the average yields for each year and for the period as a whole were much higher than in any variant involving only one of these fertilizers. As compared to the control plot, P fertilizer applied by itself failed to increase the fodder yield. Combined with N fertilizer, P fertilizer did not lead to a higher yield than that obtained when N fertilizer was applied by itself. Only when P fertilizer was applied in combination with N and K fertilizers was the fodder yield notably higher, and the highest yield was obtained with an aggregate NPKMo fertilizer introduction. However the PKMo fertilizer combination proved to be economically the most effective.

Key words: nitrogen, phosphorus, potassium, molybdenum, alfalfa, hardiness, yield.

3-6-4 Phytotoxic Response of Five Range Grass Species to Six *In Situ* Fossil Fuel Retort Waters

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Oil shale, tar sands and underground coal gasification represent viable sources of fossil fuel to assist meeting U.S. energy needs. Development of fossil fuel processing technologies has progressed to a point where commercialization may soon become a reality. Concurrent with this development must be the assessment and solution of environmental problems. A particular and significant problem resides in the handling, containment, treatment, disposal, use and eventual fate of waters recovered with the oil, gas and subsurface waters associated with synfuel processing techniques. The magnitude of plant responses and potential phytotoxic effects resulting from exposure to these produced waters has not been evaluated, but needs to be quantified for purposes of risk assessment. To address this problem, research was conducted to: 1) develop or test quantitative short-term, cost-effective, diagnostic screening procedures for testing vegetation against synfuel produced waters, 2) using such procedures to quantitate the response of plants to these waters and 3) provide information for developing controlled technology. Growth responses (leaf area, dry weight, root/shoot ratio and leaf/shoot ratio) as well as germination were parameters monitored to test produced waters against vegetation under greenhouse conditions using hydroponic techniques. Grass species respond differently to an individual water and in turn may react in changing orders of response to several waters originating from retorting various fossil fuels. Growth response varies with dilution and may be more valuable as an indicator of phytotoxicity than germination. Plant species response to various waters can be separated and ranked to allow risk assessment, facilitate selecting the correct species for reclamation and will in the future be able to assess the success of water treatment procedures.

Key words: fossil fuel, water, germination, growth response, vegetation.

3-6-5 Response of Hybrid Pennesetum and *Panicum maximum* J. to Different Levels of Nitrogen and Irrigation

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Hybrid pennesetum and Guinea grass (*Panicum maximum* J.) have been introduced in the Punjab State to extend fodder supply to lean periods. The objective of this study was to determine the nitrogen (N) and irrigation requirements for sustained high level production of these grasses in Samana sandy loam (typic ustochrept) soil. N rates 0, 50, 75, and 100 kg/ha/cutting were combined with three water regimes in which irrigation was scheduled according to IW/PAN-E of 0.90, 0.55, and 0.40 for spring cutting and 1.0, 0.7, and 0.5 in summer. IW refers to the depth of irrigation water applied (7 cm) and PAN-E to the open pan evaporation during the irrigation interval.

The forage yield in both grasses was strongly influenced by sun shine hours. Summer cutting produced 12.81 t/ha dry matter as against 7.8 t/ha in the spring cutting of same duration. Guinea grass yields were higher in both cuttings. Forage yields increased with increase in N rate, but the response decreased at the highest N rate. The average response to N at 100 kg/ha was 2.40 and 5.86 t/ha in spring and summer cuttings, respectively. The effect of irrigation interval was more pronounced in summer when an average yield difference of about 3 t/ha was recorded between the shorter irrigation intervals (high IW/PAN-E) and longer irrigation intervals (low IW/PAN-E). Unlike spring, a significant interaction was observed between N rates and irrigation in the summer cutting. The uptake of N did not differ between the grasses but was significantly influenced by irrigation and N levels. Nitrogen content in the summer cutting was 121.2 and 268.4 kg/ha in guinea grass and 133.5 and 252.1 kg/ha in hybrid napier at N rates of 0 and 100 kg/ha.

Key words: hybrid pennesetum, guinea grass, *Panicum maximum* J., irrigation, forage yield, N uptake.

3-7-1

Prediction of the Supply of Soil Nitrogen to Grass

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Prediction of the supply of soil nitrogen (N) to grass over a growing season requires an assessment of nitrate-N plus ammonium-N (i) present in the soil at the beginning of the season and (ii) likely to be released from the potentially mineralisable organic N during the season. While a number of methods have been proposed for predicting soil N supply, and in particular the component arising from the potentially mineralisable N, many are too lengthy for routine use, and with others there is a lack of evidence of their effectiveness over a range of soils. However in recent studies, the measurement of nitrate-N plus ammonium-N, extracted either (a) by boiling with 1M or 2M KCl or (b) by shaking with 0.05M $Ba(OH)_2$, was found to account for 80% of the variation in the yield of N in the herbage of perennial ryegrass grown in pots on 21 soils under uniform environmental conditions. The prediction of soil N supply in the field, over 18 sites in the U.K., was substantially improved when the results of soil analysis were adjusted by a factor, calculated for each site, based on mean values of temperature and soil water status.

Key words: nitrogen, soil, mineralisation, perennial ryegrass *Lolium perenne* L., analysis.

3-7-2

Soil Nutrient Constraints for Legume-based Pastures in the Brazilian Cerrados

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Soil nutrient deficiencies in two Cerrados soils have been investigated as a preliminary to small plot research oriented to estimate fertilizer requirements for establishment and persistence of legumes in grass-legume associations. The studies were conducted in the greenhouse, in 2 kg pots, with surface soil samples taken from two sites representative of the dominant soils in the region. These are the Dark Red Latosol (DRL) and the Red Yellow Latosol (RYL) which qualify as HAPLUSTOX and ACRUSTOX respectively. Two kinds of experiments were carried out. One consisted of a 1/4 replicate of a 2^8 factorial including Potassium (K), Calcium (Ca), magnesium (Mg), Sulfur (S), Zinc (Zn), Molybdenum (Mo), Copper (Cu), Manganese (Mn) and Boron (B) in which Cu and Mn were applied together as a single factor. Levels of these nutrients were 0 or 80, 200, 20, 30, 2, 0.27, 2, 2 and 1 parts per two millions parts of soil (pp2m) respectively. All pots received monocalcium phosphate ($Ca(H_2PO_4)_2 \cdot 2H_2O$) at a rate of 100 P pp2m. A second experiment consisted of four levels of P (50, 100, 200 and 400 pp2m) and four levels of Ca (0, 40, 200 and 400 pp2m) as $CaCO_3$, with basal application of all other nutrients and rates used in the previous experiment. Test plants used were calopo (Calopogonium mucunoides Desv.), a Centrosema (Benth) species CIAT 438, stylo (Stylosanthes guianensis Aubl.) CIAT 2243 and Gamba grass (Andropogon gayanus var. bisquamulatus (Hochst. Hack) CIAT 621.

Results showed a clear response to P up to 200 P pp2m in both soils, when Gamba grass or stylo was used and up to 400 P pp2m when the Centrosema sp. or calopo was used. Response to the highest levels were more evident in the RYL soil. In all species Ca improved plant responses to low levels of P. Maximum yields were also increased except in the case of stylo.

In the second experiment it was observed that S was deficient in both soils for all test plants, as measured by plant responses to applied S. Potassium responses were also observed in both soils, while Ca response was more common in the RYL Soil. Magnesium response was observed only in the RYL soil when Gamba grass was used as a test plant. Molybdenum and Zn deficiencies were observed in both soils with some of legumes.

The results demonstrate the importance of S, Ca, Mg, K, Mo and Zn deficiencies after P deficiency has been corrected. Based on these observations, field experiments have been established to define the required amounts of S and K and to confirm under field conditions the need for Ca, Mg, Mo and Zn.

Key words: soils, sulfur, micronutrients, lime, phosphorus, legumes, Andropogon gayanus Kunth.

3-7-3

Pasture Production and Changes in Soil Fertility in a Long-Term Irrigated Superphosphate Trial at Winchmore, New Zealand

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The Winchmore long-term superphosphate trial was commenced in 1952 with the aim of investigating the superphosphate requirements of irrigated ryegrass/white clover pasture under grazing. Although these requirements were established in the first few years, the trial was continued to provide data on (i) changes in soil nutrient status with time, (ii) residual effects of superphosphate, and (iii) nutrient cycling.

The trial contains five treatments, viz (1) control (no superphosphate); (2) 188 kg/ha annually; (3) 376 kg/ha annually until 1957, none since; (4) 564 kg/ha annually until 1957, none since; (5) 376 kg/ha annually. Each treatment is grazed with a separate flock of dry ewes, which rotate around the four replicates of each treatment. Soil (sampled annually) and pasture samples (each cut) are retained for analysis.

Treatments 1, 2 and 5 have produced an annual average of 4.3, 10.0 and 11.2 t/ha dry matter respectively. Production on the control is being maintained by the weathering of native mineral P and by the input of S in irrigation water and rainfall. Treatment 4 produced only 4% more dry matter than treatment 5 before superphosphate application was stopped, in 1957, in order to study residual effects. Production on treatments 3 and 4 has shown a continuous decline since the cessation of superphosphate application.

Topsoil organic carbon, nitrogen and sulphur reached plateaus on all treatments after 10-15 years. Organic phosphorus (P) showed a linear increase on all treatments until the trial was limed (4 t/ha) in 1972, which increased the pH from 5.9 to 6.6. Following the liming, accumulation of organic P ceased. Prior to liming, total inorganic P had been declining on treatment 1 (control) and on the residual treatments (3 and 4) and increasing on treatment 5. Following the liming, the previous accumulation of organic P was reflected as a positive change in non-occluded P (i.e. aluminium and iron-bound P), but not in either Olsen P or in increased plant uptake. This apparent contradiction may have been due to the formation of aluminium and iron phosphate coatings on the lime particles; these should become available to plants as the lime dissolves.

The results of this long-term trial have shown the importance of the continuing accumulation of soil organic P on maintenance superphosphate requirements, and has led to further studies to determine (i) whether this accumulation is general in New Zealand's temperate climate at pH below 6.0, and (ii) to what extent this accumulation can be reduced, and soil P availability increased, on different soils in New Zealand. The study will include an investigation on the forms of soil organic P and their relative susceptibility to mineralisation.

Keywords: superphosphate requirements, irrigated pasture, soil fertility, pasture production, phosphorus cycling, organic phosphorus.

3-7-4 Effects of Phosphate and Potash on Mineralization of Meadow Soil

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Plants derive nutrients from resources of the ecosystem and from fertilizers. Application of fertilizers stimulate not only the growth of plants but also the activity of other organisms including the mineralizers of the dead organic matter. The soil of permanent grassland is characterized by a comparatively high content of nitrogen (N) most of which is fixed to the organic matter.

The aim of this experiment was to investigate the extent of the N-mineralization with different applications of commercial fertilizers on incubated soil samples of the upper layer (0 - 10cm) of a typical fresh meadow of the vicinity of Giessen/Hessen, West-Germany. The soil contained about 10mg P_2O_5 and K_2O/100g soil. The total N-content in this layer was about 500mg N/100g soil and the amount of exchangeable ammonium reached 2mg N/100g soil. The treatments of the two factorial trials were equivalent to 0, 200 and 400kg P_2O_5/ha as superphosphate, and 0, 200, 400, 800 and 1200kg K_2O/ha as KCl 62%. The experiment was carried out in an incubator at 22° C and 50% water-capacity. Ammonium and nitrate were determinated by double distillation 4 times during the incubation period. of 8 weeks.

With progressing incubation time the amount of total mineralized N increased. At the end of the incubation period the amount of nitrate-N went up significantly. Increasing amounts of potash fertilization increased the proportion of mineralized N at all 4 determination dates. The application of phosphate caused an increase of the N-mineralization only after 1 week of incubation. At the other dates the effect of the phosphate application was not significant. The interaction between the two treatments was significant only after 1 and 2 weeks of incubation. The ratio of ammonium-N to nitrate-N was higher with increasing application of the fertilizers either alone or together. After 8 weeks of incubation the control without application of fertilizers reached a content of mineralized N of 29mg N/100g soil. The ratio was about 1:1. The maximal application of phosphate caused a ratio of 5:1. The maximal potash application caused an amount of mineralized N of 42mg N/100g soil and the ratio went up to 20:1.

The results show the possibility of increasing the N-mineralization with applications of potash. The increased amount of mineralized N cannot be attributed only to the higher content of plant-available potassium in the soil samples; it must be attributed also to the effect of sulfate and chloride contained in the applied fertilizer.

Key words: N-mineralization, phosphate, potash, incubation, soil.

4-1-1 Interactions Between Grasses and Rhizosphere Nitrogen-Fixing Bacteria

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Sorghum and Digitaria cultivars grown in soil or nutrient solutions were inoculated with a strain of Azospirillum in short-term glasshouse experiments Carbon compounds lost by roots in solution culture experiments were determined, in order to estimate the quantity of energy substrates that might be obtained by rhizosphere organisms from growing plants. Other plants were treated with plant growth hormones, and responses were compared to those of plants which received the Azospirillum inoculum. The similarity of the responses suggests that growth hormone production by the inoculant organism, rather than nitrogen fixation, is responsible for part or all of the increase in plant growth rate.

The estimated quantity of reduced carbon compounds (lysate) lost by roots to the nutrient medium would support substantial nitrogen fixation activity if all were used for that purpose, but this clearly is not the case. The available evidence indicates instead that relatively little may be so used. This, the recognized low nitrogen fixation efficiency of free-living heterotrophs, and the demonstrated response of plants to bacterial growth hormones, suggest that benefits from inoculation, even though they may be highly important in some circumstances, need not be involved with nitrogen fixation.

Key words: plant growth hormones, nitrogen fixation, soil bacteria, root lysate, rhizosphere.

4-1-2 Microbial Associations and Nitrogen Fixation in the Rhizosphere of Some Tropical Grasses

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Inadequate nitrogen for crop growth in humid tropical soils and the ever increasing costs of nitrogenous fertilizers were factors that led to a programme of investigating cheaper means of increasing soil nitrogen and maintaining grass pastures through biological nitrogen fixation symbiotically, or non-symbiotically in the rhizosphere of grasses.

Under the non-symbiotic nitrogen fixation programme, the rhizosphere population and the relative abundance of different bacterial species in the rhizosphere were determined in a range of pastures and wildly growing grass species. The abundance of microorganisms within the rhizosphere and relative abundance of organisms capable of growth in a nitrogen-free medium formed the basis for selecting promising grass/bacterial associations for more precise and detailed investigations on nitrogen fixation in the rhizosphere involving the use of acetylene reduction and the isotopically labelled 15_N technique.

The ability of microorganisms within the rhizosphere to fix nitrogen was qualitatively assessed by acetylene reduction and quantitatively by the isotope dilution technique using 15_N in sand and soil cultures.

Delta 15_N values were also compared by taking leaf samples of a wide range of grasses and correlating these with the bacterial population of the rhizosphere.

Results of quantitative determinations of nitrogen fixation showed a variation in the rhizosphere population in terms of total numbers and the proportion of nitrogen fixers but one pasture grass, IBX-7 (an interspecific hybrid between *Cynodon nlemfuensis* var. *nlemfuensis* x *C. dactylon* var. *aridus*.), was most outstanding in having a high microbial population and was found to have fixed nitrogen at the rate of 1 kg N/ha per week. This probably explains the very high performance of this grass and its ability to remain green without nitrogen application when surrounding grasses show stress of nitrogen deficiency.

Key words: tropical grasses, nitrogen fixation, *Cynodon nlemfuensis*, *Cynodon dactylon*.

4-1-3 Selection of *Rhizobium* Strains for Enhanced Dinitrogen Fixation in Forage Legume Production

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A set of procedures on the selection of *Rhizobium* strains for enhanced dinitrogen fixation in forage legumes is presented. While forage legumes are among the most efficient members of the Leguminosae regarding biological nitrogen fixation (BNF), these legumes are generally neither productive nor persistent without effective nodulation by appropriate rhizobia. The following methods involve a selection and evaluation process to obtain appropriate *Rhizobium* strains. These include 1) regional survey of the production area, 2) strain collection and soil analysis, 3) strain characterization, 4) strain selection and manipulation, and 5) field evaluation of strains.

The initial procedure is a survey of the region where the host legume is produced. This is necessary to obtain soil and plant samples, become familiar with the major soil/climatic zones within the region, and to select potential field sites. Specific sampling sites chosen within each zone based on the history of the legume host are used to collect soil and plant samples for analysis and nodule isolations. At least ten *Rhizobium* isolates should be recovered from each site and the plant infection assay should be used to determine the size of the indigenous *Rhizobium* populations.

To characterize the effectiveness of the *Rhizobium* isolates on those host plant cultivars which are grown in the region is the most important criterion. Other methods which may help in selecting strains for field trials might include growth in acidified media, salt tolerance, and survival under moisture/temperature extremes. In order to measure strain performance in the field it frequently becomes necessary to genetically mark *Rhizobium* strains so that they can be identified when recovered from nodules. Antibiotic resistance and/or serology are the techniques of choice although there are problems with both. Eventually field plots will become cross-contaminated with different strains and then identification of each strain is the only way that the evaluations can proceed.

Field plots should be designed with at least four replicates and appropriate uninoculated controls. Data should consist of plant dry weights, nitrogen content, nodulation score, and root and leaf stage from samplings every 6 or 8 weeks. Nodule occupancy tests should focus on those strains which over time are found to be most productive in BNF and host plant responses. The best strains from the field tests should be considered for inclusion in inoculants or used in some distribution system for wider testing at the producer level.

Key words: clover, *Rhizobium*, forage legumes, nitrogen-fixation.

4-1-4 Interaction Between Alfalfa Cultivars and *Rhyzobium* Strains for Acetylene Reduction

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Two experiments were conducted to study the interactions between alfalfa cultivars (*Medicago sativa* L.) and strains of *Rhyzobium melilot* for a number of characters such as acetylene reduction rate, plant height; root, shoot, and plant dry weight. Experiment I involved 15 alfalfa cultivars, each inoculated with 10 single *Rhyzobium* strains. In experiment II, 25 host cultivars, 10 single strains of *Rhyzobium* and one commercial inoculant were used. Alfalfa seedlings were grown in vermiculite and supplied with nitrogen free nutrient solution under greenhouse conditions.

The cultivars DuPuits, Saranac, Thor (in both experiemtns); Alfa, Agnus (in experiment I); Algonquin and Arc (in experiment II), produced vigorous seedlings with high plant dry weight and high acetylene reduction rate. Conversely, seedlings from most of the western Canadian cultivars such as Roamer, Drylander, Rangelander and Anik (*M. falcata* L.) had low plant dry weight and low acetylene reduction rate. *Rhyzobium* strains NRG 118, NRG 61, A2 and 3D0a8 were among the best under study.

The analysis of variance in both experiments showed that the general effects of both alfalfa cultivars and *Rhyzobium* strains, and the specific effects of their interactions were highly significant for all characters. Further partition of these three sources of variance into their components revealed that in experiment I, more than 30 percent of the total variation for plant dry weight and 23 percent of the total variation for acetylene reduction were due to alfalfa cultivars. *Rhyzobium* strains accounted for 15 percent of the total variation for root dry weight, 30 percent for shoot dry weight, and 26 percent for both plant dry weight and acetylene reduction rate. More than 36 percent of the total variation for acetylene reduction was attributed to the alfalfa cultivar x *Rhyzobium* strain interaction. In experiment II, the variance components showed that *Rhyzobium* strains (ranged from 25 to 31 percent) were more important than alfalfa cultivars for almost all characters except for acetylene reduction, where equal amount of variations (8 percent) were obtained. The specific effects of cultivar x strain interactions again contributed a major portion of the total variation for all characters (ranged from 34 to 57 percent). In both experiments the error variances were relatively small for most the characters studied.

These results demonstrated the existence of a large amount of non-additive variation for acetylene reduction rate and other plant characters. Therefore, an effective way for improving nitrogen fixation in alfalfa is to select for a favorable combination of specific *Rhyzobium* strain and alfalfa cultivar to achieve maximum productivity.

Key words: *Medicago sativa* L., *Rhyzobium meliloti*, acetylene reduction, plant growth, nitrogen fixation.

4-2-1 Photosynthate Supply and Nitrogen Fixation in Forage Legumes

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Photosynthate supply is known to limit nitrogen (N_2) fixation in grain legumes and the resulting shortfall in energy supply necessary for maximum crop production may be aggravated by the energy wasteful process of hydrogen (H_2) evolution by the legume N_2 fixing system. There is less information available on these aspects of the nitrogen fixing process in forage legumes such as white clover (Trifolium repens). The objectives of the present work were to determine how $N_2(C_2H_2)$ fixation and H_2 production are influenced by carbohydrate supply in forage legumes.

Plants were grown under controlled environmental conditions and nodule energy supply was varied by adjusting either photoperiod or atmospheric carbon dioxide concentration. The effect of these treatments on $N_2(C_2H_2)$ fixation and H_2 evolution by both intact plants and nodulated root segments was determined.

Light-induced diurnal variation in $N_2(C_2H_2)$ fixation by intact S100 white clover (at constant temperature 20°) is related to the duration of the prior photoperiod. Short photoperiod plants (6 hour) show a diurnal effect. Plants in a 14 hour photoperiod showed a constant $N_2(C_2H_2)$ fixation rate throughout the light and dark periods. Fixation rate of these plants was double that of the 6 hour plants during the photoperiod and this was related to increased nodule mass. Specific activity ($N_2(C_2H_2)$/mg nodule/h^{-1}) was similar for both treatments during the light cycle. Activity of nodulated root segments from both light treatments showed diurnal variation and response to light was greater for the long photoperiod plants.

Plants growing in the short photoperiod evolved more H_2 to $N_2(C_2H_2)$ fixed than did long photoperiod plants.

Atmospheric enrichment with carbon dioxide did not affect the $N_2(C_2H_2)$ fixation of a number of forage legume species when measurements were made within days of commencement of treatment. After 3 weeks enrichment activity per plant was doubled and this was associated with an increased nodule mass. Specific $N_2(C_2H_2)$ fixation was not affected.

It is concluded that length of photoperiod and integrity of the plant system are important determinants of light induced diurnal variation in $N_2(C_2H_2)$ fixation. Photosynthate supply limits nodulation rather than $N_2(C_2H_2)$ fixation per se and short photoperiod plants have reduced efficiencies of $N_2(C_2H_2)$ fixation in terms of H_2 evolved relative to $N_2(C_2H_2)$ fixed.

The results show that constant rates of $N_2(C_2H_2)$ fixation in forage legumes can be maintained during the light and dark periods by carbohydrate reserves in the plant, and that photosynthate supply is not limiting for nodule activity. Conditions which deplete these reserves decrease rates of dark fixation and energy loss though H_2 evolution is not reduced even in carbon stressed plants.

Key words: nitrogen fixation, forage legume, photosynthate supply, hydrogen production.

4-2-2

Symbiotic Nitrogen Fixation of Alfalfa, Birdsfoot Trefoil, and Red Clover

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Forage legumes such as alfalfa (Medicago sativa L.), birdsfoot trefoil (Lotus corniculatus L.) and red clover (Trifolium repens L.) grown in crop rotations can provide an inexpensive source of nitrogen to succeeding crops. Few quantitative measurements of seasonal patterns of nitrogen fixation in managed communities of perennial forage legumes have been undertaken, chiefly because of the lack of satisfactory methods. Therefore, there is little knowledge of how nitrogen fixation varies with crop development, yielding ability, and weather patterns. Quantitative measurements of nitrogen fixation are important in choosing the appropriate legume for use in a crop rotation, and for understanding the constraints to nitrogen fixation in normally managed crop communities. Our objectives were to compare the nitrogen fixation patterns of alfalfa, birdsfoot trefoil, and red clover under field conditions in two successive years, and to relate these seasonal changes in symbiotic activity to dry matter yield, leaf area, and precipitation.

Nitrogen fixation was measured by the ^{15}N isotope dilution technique, in which the isotope composition of the nitrogen of the legume was compared by mass spectrometry with that of a perennial grass used as the non nitrogen fixing control.

In the seeding year the proportion of plant nitrogen derived from symbiosis ranged from 27 to 50% among species at the first harvest, and from 66 to 80% among species at the second harvest. Seasonal nitrogen fixation was greater for alfalfa (15.9 g N/m^2) than for either red clover (11.9 g N/m^2) or birdsfoot trefoil (10.6 g N/m^2). Nitrogen fixation varied significantly among harvests and among the species at individual harvests.

In the second year the proportion of plant nitrogen from symbiosis ranged from 0 to 62% at the first harvest and 32 to 60% at second harvest. Alfalfa was the only species harvested a third time, and it contained 35% nitrogen from symbiosis. Seasonal nitrogen fixation for alfalfa (17.1 g N/m^2) was again greater than that of red clover (9.8 g N/m^2) or birdsfoot trefoil (7.6 g N/m^2). Nitrogen fixation of alfalfa was more sensitive to heavy midsummer rainfall than was that of birdsfoot trefoil or red clover.

On a seasonal basis, alfalfa, the highest yielding species, fixed more nitrogen per land area than birdsfoot trefoil, the lowest yielding species. Within an individual harvest nitrogen fixation was not closely associated with yield because the high yields common early in the growing season contained less nitrogen from symbiosis than did lower yields obtained later in the season.

The results clearly show that nitrogen fixation capability varies significantly with species of forage legume. Nitrogen fixation also varies significantly with management and environmental factors that affect plant development and total nitrogen yield.

Key words: nitrogen fixation, isotope dilution technique, perennial legumes, Medicago sativa L., Lotus corniculatus L., Trifolium repens L.

4-2-3 Effect of Plant Genotype on Dinitrogen (C_2H_2) Fixation Efficiency in *Trifolium incarnatum* L.

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The contribution of dinitrogen fixation by *Trifolium-Rhizobium* symbiosis to grassland agriculture is well documented. Our efforts to improve dinitrogen fixation efficiency in crimson clover (*Trifolium incarnatum* L.) have been directed toward the plant genotype components of the symbiosis. Our objectives in studies with crimson clover were to: 1) develop a non-destructive screening technique for estimating the dinitrogen fixation efficiency; 2) determine if genetic variation in dinitrogen fixation exists among breeding lines or varieties; and 3) determine the inheritance of traits associated with dinitrogen fixation.

An acetylene reduction assay was used to screen inbred lines for variation in estimated dinitrogen fixation efficiency. In order to evaluate the plant genotype, the rhizobium component was held constant by inoculation with a single strain of *Rhizobium trifolii*. A technique was developed that allowed live plants to be assayed under the same light, temperature and moisture regimes used for growth. The plants were grown and assayed in plastic pouches containing a nitrogen-free nutrient solution.

In two separate experiments, estimates of dinitrogen fixation were found to be significantly different among lines. Other plant characteristics were measured and found to be correlated with the assay values. The inbred lines of crimson clover from these experiments were crossed in the greenhouse in a diallel mating design. In another experiment, selections were made within a large population of an open-pollinated variety for those characteristics that showed the highest correlation with an estimate of dinitrogen fixation. Final selection was based on an acetylene reduction assay and selected plants were grown to maturity and intercrossed.

These experiments indicate that the crimson clover genotype has a direct and measurable effect on dinitrogen fixation efficiency. Assay of progeny from the diallel and from the selection experiment will provide a better understanding of the role of the plant genotype in the process of symbiotic dinitrogen fixation in crimson clover.

Key words: crimson clover, *Trifolium incarnatum* L., dinitrogen fixation, acetylene reduction.

4-2-4

Effects of Grazing Management on Seasonal Variation in Nitrogen Fixation

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Using the acetylene reduction assay, field studies in recent years have investigated the variation in N-fixation in grazed systems, and some of the principles involved in the interaction with available soil N have been described. This experiment extends this work to include the effect of grazing management on the factors influencing N-fixation.

Two self contained sheep grazed units, one a 10 paddock rotationally grazed system, and the other set stocked, were established on a high fertility ryegrass/white clover pasture, with a basic stocking rate of 22 sheep/ha. Over the 1975-78 period both units were monitored for pasture growth, N-fixation and associated herbage and soil parameters.

Annual N-fixation under set stocking was 10% higher than under rotational grazing. The difference occurred during the dry summer-autumn period and reflected a greater ability of the set stocked pastures to respond to short term alleviation of moisture stress. Legume growth rate was the principal factor controlling N-fixation in both systems. Available soil N appeared to be of greater significance in controlling N-fixation under rotational grazing. This was consistent with the generally lower herbage NO3-N levels found under set stocking. These differences were attributed to differences in sward structure and physiological stress between the two grazing systems.

Key words: N-fixation, available soil N, legume growth, grazing management, herbage nitrate.

4-2-5 Nitrogen Use Efficiency of Legume-Grass and Grass Pastures

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In the subhumid to humid, temperate regions of the world, nitrogen (N) availability is very often the factor most limiting to pasture productivity, both in terms of dry matter yield and animal performance. Because of increasing energy costs of producing N fertilizer, possibilities for improving the efficiency of pasture N use must be explored. This study was designed to characterize the N status of two N-forage systems and to estimate the animal use efficiency of pasture N at two grazing pressures.

The experimental pastures consisted of an alfalfa-smooth bromegrass-orchardgrass (Medicago sativa L., Bromus inermis Leyss., Dactylis glomerata L.) (A-B-O) mixture receiving no N fertilizer and reed canarygrass (Phalaris arundinacea L.) (RC) receiving 180 kg N/ha, annually, each type of pasture grazed at moderate and heavy grazing pressures, in two replications. The pastures were located in southern Iowa, U.S.A. Data for the following were recorded: soil total N and organic carbon (C), herbage dry matter yield, percentage N of herbage, ungrazed herbage, percentage N of ungrazed herbage, percentage legume by visual estimate and manual separarion, in situ N_2 fixation using ^{15}N microplots, and animal weight gains. Beef steers with initial weights of ca. 250 kg grazed the pastures for approximately six months in a put-and-take, rotational system in 1979 and 1980.

Means for the two years are summarized here. Average forage dry matter yields were 5852 and 7974 kg/ha for the A-B-O and RC pastures, respectively. Harvestable N yields were 160 and 245 kg/ha, respectively. Values for ^{15}N dilution indicated that 90% of the legume herbage N and 38% of A-B-O N was symbiotically derived, an input of 65 kg/ha. The A-B-O sward consisted of 35% alfalfa. Ungrazed herbage N, measured as an index of herbage N return to the soil, was 34 and 58 kg/ha in the A-B-O and RC pastures, and 49 and 43 kg/ha for moderate and heavy grazing pressures, respectively. Soil total N and organic C levels were consistently higher in the RC pastures and in pastures of heavy grazing pressure. Animal gain per ha, using tester animal average daily gain, was 346 and 426 kg/ha for A-B-O and RC, respectively, and 386 kg/ha for both grazing pressures.

As indices of N use efficiency in the pasture, ratios of herbage dry matter, herbage N and beef gain/ha per unit of N input (either by N fixation or N fertilizer) in A-B-O were 2X those of RC. There was greater N accumulation in herbage residue and the soil in RC. Though herbage and beef production was lower in A-B-O, it supported a higher level of beef production per unit of N input.

Key words: alfalfa, smooth bromegrass, orchardgrass, reed canarygrass, nitrogen cycle, nitrogen fixation, cattle.

4-3-1

Nitrogen Losses from Urine-Affected Areas of a New Zealand Pasture Under Contrasting Seasonal Conditions

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Grazing ruminants aggregate large quantities of forage nitrogen (N) into urine patches. Pasture plots treated with urine-N were studied to assess its fate under contrasting seasonal conditions: cool-moist (representing winter-spring); warm-moist (late spring-early summer), and warm-dry (late summer-autumn).

A permanent ryegrass (Lolium perenne L.)-white clover (Trifolium repens L.) sward on free-draining alluvial soil was studied. Treatments were replicated in randomised blocks. Urine-N was applied to 3-m^2 plots at rates of 30 or 60 g N/m^2. Relevant measurements were then continued in soil and herbage until treatment differences disappeared. Apparent N balances for urine treatments were compiled.

Hydrolysis of urea-N was always essentially complete within 24 hours. Much of the urine-N was recoverable as NH_4-N during the first week. Thereafter, NH_4-N declined to control levels over 3 to 10 weeks, the rate depending on environmental conditions. Nitrate-N accumulated as nitrification proceeded, reaching peak values some 3 to 7 weeks after urine-N application. It subsequently disappeared from the profile under leaching conditions.

On average, 5%, 16% and 66% of added urine-N volatilized as NH_3-N, under cool-moist, warm-moist, and warm-dry conditions, respectively. Volatilization was rapid, with 75% of NH_3-N evolved during the initial 3 days, irrespective of season.

In all three experiments N fixation by white clover was greatly reduced in urine-affected swards. Urine-N increased herbage-N yield only when moist conditions favoured plant growth. Overall, apparent recovery of urine-N by pasture averaged 37%, and ranged from 55% under cool-moist to 11% under warm-dry conditions. Soil total N was unaffected by treatments.

Some two-thirds of urine-N was lost from the soil-plant system during these studies. Extremes in average loss were 45% (and 80%) under cool-moist (and warm-dry) conditions. Much added N was lost through an undefined combination of leaching and denitrification. Volatilization of NH_3-N was the major pathway only under warm-dry conditions.

Nutrient recycling in the excreta of grazing animals is generally considered beneficial to pasture production, and the major pathway for transfer of clover-fixed N to grass associates. The authors dispute those views with respect to N. Rather, they contend that grazing ruminants cause substantial N losses from developed pastoral ecosystems.

Sheep or cattle grazing well managed grass-clover pastures in New Zealand excrete several hundred kg urine-N/ha/year. The more intensively utilised of these systems may be in negative N balance, largely because of N escape from urine patches.

Key words: N cycle, N losses, urinary N, ammonia volatilization, nitrate leaching.

4-3-2

Annual Losses of Ammonia from a Grazed Pasture Fertilized with Urea

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Nitrogen balance studies have shown losses of applied nitrogen (N) from grazed pastures in S.E. Queensland. Losses as high as 80% have been observed from urea-N broadcast at 376 kg N/ha/year over 8 years on a Setaria sphacelata cv nandi pasture. Management techniques aimed at reducing this loss and thereby increasing the efficiency of use of N by pastures cannot be devised until the pathways of loss are known. The objective of this research was to estimate the annual loss by convective transport of gaseous ammonia from a urea-fertilized pasture at Samford Pasture Research Station in S.E. Queensland.

Urea was broadcast onto a grazed pasture at 94 kg N/ha in February, May, August and November 1978 and February 1979. Ammonia fluxes above the pasture were estimated by the momentum balance method, which uses micrometeorological measurements and the ammonia concentration profiles in the air above the pasture. Fluxes were measured for 24-hour periods on the day before urea application, on the day of application, then on the 2nd, 4th, 7th, 10th, 14th and 50th days. Supporting soil data, including temperature, pH, water and mineral N contents were also obtained.

The annual net loss was estimated to be 90.7 kg N/ha, equivalent to 24% of the applied N. Eighty-two per cent of the loss occurred within two weeks of application. The greatest loss was from the May fertilizer application, when in two weeks losses were 42% of the applied N, while on the other occasions losses ranged from 9 to 13%.

Days when there was a net gain of ammonia-N by the pasture from the atmosphere were common. This demonstrates that the pasture is both a source and a sink for atmospheric ammonia.

The estimated loss of 24% of applied N does not fully explain losses observed in previous work. Other loss pathways including denitrification and leaching now need to be assessed.

Key words: ammonia volatilization, Setaria sphacelata, urea, cattle, and nitrogen loss.

4-3-3-

Fate of Nitrogen Applied to Grassland in Animal Wastes

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The experiment was designed to determine the effects of land spreading of animal manures on the nutrient content of surface runoff water and infiltrating soil water. This report deals only with nitrogen (N) and attempts to quantify the losses through runoff, leaching and volatilisation of ammonia as well as N uptake in the grass over a three year period.

Experimental plots sited on grassland, on two soil types (a moderately drained loam and an impermeable qley), were equipped to collect surface runoff water. Ceramic probes were installed in each plot at 15, 30, 60 and 100 cm depths to extract infiltrating soil water. Pig slurry was applied at three different rates, three times each year. Inorganic fertiliser and control plots were included. Volatilisation of ammonia and nitrification were determined by daily analyses of soils following slurry application. Grass was harvested three times each year.

The results indicate that 40-80% of the slurry ammonium nitrogen (NH_4^+-N) was lost through volatilisation of ammonia within ~7 days of application. In the moderately drained soil, nitrification of the remaining nitrogen occurred as shown both by soil analyses and by subsequent appearance of nitrate nitrogen (NO_3^--N) in the soil water. The leaching losses increased as rate of slurry application increased and were estimated to account for ~5% of the total applied N at the lowest rate of slurry application and ~13% at the highest rate. Leaching losses from fertiliser were comparatively higher than from slurry .

At the impermeable site NO_3^--N was absent from the soil water of slurry treatments during the first two years of the experiment. It was not clear if nitrification was inhibited in the waterlogged soil but there was evidence to suggest that nitrification in the top few centimetres of soil may have been followed by rapid denitrification in the anaerobic subsurface soil.

Rainstorms causing runoff did not occur for several weeks following most of the treatment application dates and therefore losses in runoff were small. The highest recorded loss was ~8% of the NH_4^+-N applied when rainstorms occurred soon after application at the impermeable site in November 1978.

N uptake in grass from slurry was very poor, ranging from 20-24% recovery from the low rate to 14-17% from the high rate. Uptake from fertiliser was 52-55% in the same period.

The results show clearly that spreading animal slurry on grass is a very inefficient method of recycling its nitrogen content. Improved efficiency would depend on alternative methods of land spreading such as injection, where losses through volatilisation of ammonia would be greatly reduced.

Key words: nitrogen, infiltration, runoff, ammonia volatilisation. animal wastes.

4-3-4 Importance of Grass-Legume Association in the Nitrogen Economy of a Tropical Grassland

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Grasses, by growing in association with legumes, take up atmospheric nitrogen fixed by legumes, showing in the process the problem of grassland management. The present investigation deals with the nitrogen economy of grazinglands having a positive association of grasses and legumes. To explain the behavior of the system, various transfer equations for nitrogen transformation have been derived. The edaphic and climatic environments had been evaluated in relation to the system-state variables. Association analysis having been quantitatively evaluated, is correlated with the edaphic environment. Further, the uptake retention and restitution of nitrogen of the system has been critically evaluated in the different subsystems and conclusion has been drawn that legumes play an important role in grassland management, being responsible for the flourishing of the grasslands as well by making nitrogen available for increasing the productivity.

Key words: legumes, nitrogen transformation, system-state variables, association analysis, edaphic environment.

5-1-1 Progress in the Development of Conservation Plant Cultivars by the USDA Soil Conservation Service

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SCS operates a coordinated network of 22 plant materials centers in the United States to assemble, evaluate, select, cooperatively release, and provide for the commercial increase of native and introduced plants for the conservation and improvement of soil, water and related resources. Standardized procedures have been developed and are being used for this comparative plant testing program. Evaluation data can be retrieved from an automatic data processing system through standardized reports. Over 140 SCS-released cultivars of conservation plants are available commercially for use in range, pasture, and other grassland improvement to reduce sediment movement and improve wildlife habitat. These improved plants are also used to solve other erosion problems including the reclamation of surface mined land, roadside development, and sand dune and shoreline stabilization. A number of new cultivars for use in grassland plantings are now available.

Key words: Soil Conservation Service, grasses, legumes, shrubs, forbs, cultivars.

5-1-2 Survival of Different Species and Varieties of Grass Used in Mixtures and Congenerous Sowing During Succeeding Years After the First Sowing

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The main objective of this research was to examine the capacity of grass species used in Poland to survive. Two ways of utilization, mowing (three times) and grazing (five pasturages) were evaluated. Yearly fertilization rates were: N, 240; P_2O_5, 80; and K_2O, 100 kg/ha.

During four years, the following species of grass were evaluated: Dactylis glomerata Fala, Phleum pratense Emma, Festuca pratensis Ola, Lolium perenne Argo and Poa pratensis SK-46. It was ascertained that the yields of mixtures were higher on meadows than on grazed pastures. In sown species, mowing had a greater effect than did grazing on sown stands. The amount of non-sown species increased with mowing and Dactylis glomerata dominated, amounting to more than 70% of the stand when its amount in the mixture was only 10%. In comparing congenerous sowings with mixtures of these species, it was noted that utilization by grazing resulted in greater amounts of the sown species, about 80%, than did utilization by mowing. Irrespective of the capacity of different grass species to survive when used in mixtures or in congenerous sowings, no differences in global yields were observed.

Key words: Dactylis glomerata, Phleum pratensis, Festuca pratensis, Lolium perenne, Poa pratensis, grazing, mowing, survival, yield.

5-1-3

Perennial Grasses for Salt-Affected Non-Irrigated Semiarid Land

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Evidence suggests that secondary salinization of irrigated and dryland farming is occurring on certain soils as a consequence of man's influence on the ecosystem. In the short history of European settlement in southern Australia, an estimated 2 x 10^5 ha of land which first supported good crops or pastures is now suitable only for halophytic species (Northcote and Skene, 1972). The problem also occurs in Canada (Greenlee, et al., 1968), and in the northern USA, where the area already affected is increasing by 10% each year (Clark, 1971). In most cases where the soils are affected by secondary salinization, there is also an increased salinity of surface water supplies from catchments (Peck, 1973).

The main soluble salt involved is sodium chloride. It is responsible for much of the salinization of soils in Australia, and is important because the accumulated salt in the surface layers is severely affecting agricultural production and is causing erosion. The dryland area affected in south-eastern Australia is estimated to be about 19,700 hectares, within a rainfall zone of between 15-80 cm per annum.

The purposes of the recent research studies in Victoria have been to identify the hydrological properties of catchments predisposed to salinization, and to select and test salt-tolerant plants in connection with ameliorative and agrotechnical methods. The material tested in Victoria in a series of experiments covered a fairly wide range of pasture plants reputed to be salt-tolerant. Experimental results showed that Paspalum vaginatum is suitable and grows well in creek beds or on small areas where prolonged winter flooding occurs. Other species such as Lolium rigidum, Phalaris tuberosa, Medicago sativa and Trifolium fragiferum are only moderately tolerant and are more suited to marginal salt areas which already support sea barley grass (Hordeum spp.).

Two perennial grasses, namely Puccinellia ciliata and Agropyron elongatum emerged as superior, by providing ground cover and pasture on bare saltpans which had previously been unproductive and susceptible to erosion. Subsequent trials confirmed that these two grasses are outstanding pasture plants for salt-affected areas, especially in the 45.7 cm to 63.5 cm rain belt on soils that contained 0.3 - 2.0% chloride in the surface, 0 - 15 cm, layer. Although they cannot be grazed in the establishment year they thicken up and can stand grazing by the second year (Zallar and Mitchell, 1970).

Recent results indicate that Agropyron elongatum and Puccinellia ciliata establish, grow and persist also under highly saline and waterlogged conditions in semi-arid north-western Victoria, where the average annual rainfall is about 35 cm.

The agronomic techniques which assisted the establishment of grasses were a rough cultivation in autumn before sowing, mulch and fertiliser applications, and fencing the area off to exclude livestock.

Key words: secondary salinization, sodium chloride, salt tolerant plants, Paspalum vaginatum, Lolium rigidum, Phalaris tuberosa, Medicago sativa, Trifolium fragiferum, Puccinellia ciliata, Agropyron elongatum.

5-1-4 Establishing Native Perennial Grasses and Forbs Using Herbicides and Mowing

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Upland and lowland sites, seeded to perennial grasses and forbs, were treated with Atrazine, 2,4-D, and mowing at one and two-year intervals to assess procedures by which to reestablish native grassland vegetation. Vegetative composition of each treatment area was evaluated in late Summer for three years following treatment.

Mowing resulted in the most diverse stand of seeded species in both lowland and upland sites (average cover/grass species = 16% and 15% respectively with 4 and 9 forb species noted). In the upland, an equally diverse stand was obtained with 2,4-D at 2.2 kg/ha. Seeded forbs were absent from all lowland plots treated with herbicides. Atrazine and 2,4-D, however, can be effective in establishing grass stands where the need for rapid establishment outweighs the desirability of diversity. Lowland native grass cover, for example, averaged 20% and 8% higher with Atrazine than in mowed and control areas.

Switchgrass (Panicum virgatum) in the lowland site was strongly favored by high concentrations of Atrazine (average cover = 96%) although other species declined. In the upland site, 2,4-D was more effective in establishing grasses than Atrazine although switchgrass was not included in the seed mixture. Sideoats grama (Bouteloua curtipendula) and blue grama (Bouteloua gracilis) were favored by 2,4-D averaging 22% and 12% cover as compared to 15% and 6% with Atrazine; little bluestem (Andropogon scoparius) cover, however, was highest with Atrazine. In both sites, Atrazine was more effective at maintaining lower forb cover (55%) than mowing (58%), 2,4-D (82%) or in the control (82%). Direct effects of Atrazine on forb establishment, including carryover effects, is suggested by these results although total canopy cover also appears to be a factor. Unmowed lowland plots, for example, averaged 1109 g/m^2 biomass in contrast to 394 g/m^2 for all upland plots and for mowed lowland plots. Seeded forbs in the lowland were found only in the mowed area.

The overall results of this study indicate that procedures for reestablishing native grassland vegetation vary, particularly with respect to topographic setting. Herbicides expedite grass establishment particularly on lowland sites although they prevent the establishment of seeded perennial forbs. Because of the questionable advisability of using herbicides, it is essential that preliminary consideration be given first to determining whether herbicides are needed and second, if needed, to selecting the lowest effective concentration. Such considerations are essential particularly since the effects of herbicides in an ecosystem in any amount are not fully understood.

Key words: grassland reestablishment, herbicides, mowing, Atrazine, 2,4-D.

5-1-5

Utah State Rangeland Development Fund: No-interest Loans Boost Range Improvements

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The State of Utah (USA) has implemented a new and innovative program for the development and improvement of privately owned range resources. Private rangeland owners and operators in Utah can receive (for an initial 4% administration fee) no-interest loans for range improvement work with up to 15 years to pay. Because it takes about two years to realize a return from most range practices, ranchers are given a two year "grace" period before pay-back starts. This new approach to range improvement is the Utah State Rangeland Development Fund which was passed into law in 1976. Since then, 100 range improvement plans have been funded for a total of 2.4 million dollars. As the money is paid back, it goes into a revolving fund and is used again to fund other range improvement projects.

Rangelands comprise 92 percent of Utah's 21 million hectares. But despite their importance, rangelands are still one of our most neglected and underdeveloped resources. Past use -- carried out with inadequate knowledge of the rangeland environment -- has caused a deterioration of many ranges. In 1970, 75 percent of privately owned rangelands in Utah were in poor-to-fair ecological condition. Many grassland communities have been replaced by nearly pure stands of species such as sagebrush (Artemisia spp.), juniper (Juniperus spp.), or cheatgrass (Bromus tectorum).

Experience and research have proven that proper resource management, along with practices such as brush management, range seeding and livestock water developments, can increase desirable forage plants as much as 5 to 10 times on some of our poorer condition rangelands. However, high costs, high interest rates and delayed returns on investments often discourage ranchers from investing in needed range improvements.

The Rangeland Development Program is administered by the State Soil Conservation Commission. Range specialists from the USDA Soil Conservation Service work closely with each borrower to help develop a conservation ranch plan that is environmentally and economically sound. The local SCD reviews the plan and sends it to the State Commission for approval and funding.

The first 5 years of the no-interest revolving fund in Utah have been very successful. Over 52,000 hectares have been cleared of competitive shrubs and seeded. Over 200 new watering facilities have been installed and nearly 500 kilometers of new fences have been constructed. Planned grazing systems have been implemented on over 200,000 hectares.

Key words: range and development, range improvement loans.

5-2-1 Effectiveness of Land-Reclamation Measures for Ensuring High Productivity of Meadows and Pastures

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Lithuanian SSR is situated in an area of excess dampness. The small territory of the republic nevertheless is notable for its variety of climatic, topographic, and soil conditions. Average annual precipitation fluctuates between 60 and 90 cm. During the vegetative period of perennial herbs the average long-term precipitation varies between 38 and 55 cm. Precipitation is highly variable within and among years with rainy and droughty periods. The average duration of the active vegetative period is 204 days with a mean air-temperature in this period of 13°C, and average annual evaporation of 35 to 40 cm.

Podzol-soils prevail with fewer areas of sod-podzol, podzol-marsh, marsh, sod-carbonate and alluvial soils. The amount of land with excess dampness is 3,645,500 ha or 55.8% of the whole territory. These areas are partly overgrown with shrubs and cluttered with stones. Complex draining and cultivating measures must be carried out to turn the areas into highly productive, cultivated meadows and pastures.

The most effective and convenient way of land-reclamation is underground drainage. Up to 1980 ca 2.4 million ha were drained and cultivated and 0.7 million ha of cultured meadows and pastures were established. The special organizations for land-reclamation create 40-45 thousand ha of cultivated meadows and pastures each year. Cultivated meadows are established on the newly developed alluvial marshy lands and cultivated pastures are established on plots of different soil types.

The increase in crop yields of meadow and pasture herbs after draining and developing the plots is 2000-2500 fodder units per ha. The economic efficiency of the development and culturing of the lands is enhanced by rational utilization of the shrub-wood and stones which are removed.

Irrigation, which is very important because of uneven distribution of precipitation during the vegetative season, increases yield of cultured pastures by 2000-4000 fodder units per ha. Irrigating cultivated pastures is considered economically practical when the crop-increase from 1 mm irrigation-water is not less than 15 fodder units per ha. The most efficient method for watering the perennial herbs is to use the flow from large cattle-breeding complexes and some of the sewage waters.

In due course the crop productivity of the cultivated meadows and pastures abates and weeds and mounds appear. Technology has been developed to revive the stunted cultivated meadows and pastures which helps to increase the crop yields in the first and second year by as much as 90 percent. To destroy the old sod and to create new, herbicide chemicals and various soil-working machines are used. The average cost of renewing the lands is 220 roubles per ha, the time of capital investment justification is up to 2 years.

Key words: wet soils, drainage, land-reclamation, irrigation, fertilization, forage yield.

5-2-2 Effects of Topsoil Depths and Species Selection on the Reclamation of Coal Strip Mine Spoils

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The objectives of the studies reported here were (1) to determine the effects of topsoil replacement on establishment of seeded vegetation on strip mine spoils, (2) to determine the effects of depth of topsoil placed over spoil on growth of intermediate wheatgrass and wheat herbage and roots, and (3) to evaluate the responses of 17 grass species when grown on topsoil and mine spoil.

In a field study in northwest Colorado, a seed mixture of range grasses, forbs and shrubs was drill-seeded on five depths of topsoil placed over surface coal mine spoils, and the effects of topsoil depth on species establishment were measured. In a greenhouse study, the effects of five depths of topsoil placed over spoils on the herbage and root yields of intermediate wheatgrass (Agropyron intermedium (Host) Beauv.) and wheat (Triticum aestivum L.) were determined. In a second greenhouse study, seventeen grasses were planted in 25 cm of topsoil over spoil and in spoil alone to evaluate species differences in herbage yield, root yield, and root distribution in topsoil and underlying spoil.

In the field planting, stand establishment averaged 1.9 times better on all topsoil depths than on spoil alone, and the density of the seeded stand increased linearly as topsoil depth increased up to the maximum of 46 cm of topsoil used in these studies. In the greenhouse, herbage yield increased linearly with the increase in topsoil depth. Root production by both species was greater in topsoil than in underlying spoil; however, intermediate wheatgrass produced two to four times more root weight in spoil than did wheat. In the second greenhouse study hard fescue (Festuca ovina duriuscula (L.) Koch), tall fescue (F. arundinacea Screb.), Arizona fescue (F. arizonica Vasey) and Russian wildrye (Elymus junceus Fisch.) had the highest total root production. The roots of hard fescue and Arizona fescue were largely confined to the topsoil while the other two species had over 35% of their total root production in the underlying spoil.

Depth of topsoil and species selection should be considered for optimum revegetation success on coal strip mine areas in the Central Rocky Mountains. The greater the topsoil depth, at least up to 46 cm, the denser the seeded stand in the field, and the greater the herbage and root production in the greenhouse. Species can be selected that will provide high root production in the topsoil, good rooting into the underlying spoil, maximum herbage yield, or a combination of these.

Key words: topsoil, reclamation, coal mine, strip mine, mine spoils, species selection.

5-2-3 Use of Grasses and Legumes in Reclamation of Land Surface-Mined for Coal

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Successful establishment of grasses and legumes is a necessary step in the reclamation process of land disturbed by surface mining. There are several key factors that play significant roles in revegetating mined land such as: (a) providing plant nutrients (e.g. phosphorus, nitrogen, potassium); (b) lime or pH adjustment; (c) preparation of a good seedbed; etc. One factor that is sometimes overlooked is the selection of adapted grass and legume species and/or varieties of each.

Tall fescue (Festuca arundinacea Schreb.) and other species within the Festuca genus ranked near the top with respect to both ground cover and forage production when seeded on graded surface-mined coal spoils. In addition, several species within the Agropyron genus, e.g. crested wheatgrass (Agropyron desertorum Shult), also produced good yields. Red top (Agrostis alba L.) and Reed canarygrass (Phalaris canariensis L.) produced some of the highest yields of individual plots, but the means ranked lower than tall fescue and the wheatgrasses.

Several varieties of perennial ryegrass (Lolium perenne L.) were tested; although they provided the best ground cover the first year, none of the varieties produced good yields the second growing season and even poorer yields were obtained the third growing season.

Although vegetative production was not as high as tall fescue, several varieties of Kentucky bluegrass (Poa pratensis L.) gave excellent ground cover all three years.

Alfalfa (Medicago sativa L.) and birdsfoot trefoil (Lotus corniculatus L.) were the top legume species with respect to forage production and ground cover. Several varieties of each were tested, but they did not differ significantly because of a large variation among reps.

Sericea lespedeza (Lespedeza cuneata G. Don) had a very poor stand the first two years, but improved with time. Alsike clover (Trifolium hybridum L.) and white clover (Trifolium repens L.) do not appear to be suited in reclamation programs.

Key words: reclamation, surface-mined coal spoils, pasture, disturbed land, grass, legumes.

5-2-4 Yield and Quality of Forage Produced on Surface Mine Spoils in Kentucky

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Pasture or hayland is a potential use for much of the more level surface-mined land in Kentucky. To determine the usefulness of several species for forage production, two study areas were established, one in the Eastern coalfield, the second in the Western coalfield. Two of these species, 'KY31' tall fescue (Festuca arundinacea Schreb.), and 'Interstate' sericea (Lespedeza cuneata Dumont G. Don) were used as a standard for comparison. Other species tested were Caucasian bluestem (Andropogon caucasicus Trin.), 'Kaw' big bluestem (Andropogon gerardi Vitman), 'Cheyenne' indiangrass (Sorghastrum nutans L. Nash), 'Blackwell' switchgrass (Panicum virgatum L.) 'Chemung' crownvetch (Coronilla varia L.), and 'Appalow' dwarf sericea (Lespedeza cuneata Dumont G. Don).

Each of these species was seeded in a randomized block design using three replications in 1976. Each plot was harvested twice each year, beginning in 1978, to determine yield, percent protein, DMD, and sugar. Analysis of variance of the data show that there are significant differences in yield percent and percent DMD among the different species. There is also significant difference in the yield of the same species between the two study areas. In eastern Kentucky, 'Blackwell' switchgrass-'Interstate' sericea lespedeza mixture harvested twice produced 435 kg/ha more forage than 'KY31' tall fescue-'Interstate' sericea lespedeza, the standard for comparison. In Western Kentucky, all species seeded alone or in mixture produced more forage than the standard tall fescue and sericea. 'Chemung' crownvetch was significantly higher in protein DMD, and yield than the two sericea lespedeza varieties.

Key words: 'Blackwell' switchgrass, 'Chemung' crownvetch, yield, proteins, DMD.

5-2-5 Restoration of Old-Field Vegetation in Qinghai Province and its Relationship to Rodent Damages

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For the purposes of understanding the restoration old-field vegetation and its succession rule, determining the influence of rodents on the restoration of old-field vegetation, providing a scientific basis for rodent control and speeding the recovery of the vegetation, an investigation was carried out on old fields in the Panpo region, Menyuan Xian, Qinghai Province during August and September, 1974.

According to the age of old fields and through contrast analysis of phytocoenology, and coefficients of differentiation, the succession of old-field vegetation may be divided into five stages: secondary bare ground; annual and biennial weeds; herbage with rhizomes and stolons; sparse patches of grass; and thick patches of grass and Cyperaceae plants. The succession rule and characteristics were analysed.

During the succession courses of vegetation, the plateau mouse hare, Ochotona curzoniae, rapidly increases in number along with the increase of better herbages of Gramineae and Cyperaceae, while the mole-rat, Myospalax fontanieri, increases and decreases in number along with the increase of herbage having rhizomes, root tubers and root axis.

The old fields in Panpo region have been restored for about fifteen years. The damage of O. curzoniae alternates with that of M. fontanieri. The result is that some areas still stay in herbage stage. When the old fields progress from the stage of secondary bare ground to that of perennial herbage, they provide adequate food and living conditions for M. fontanieri which reproduces in large numbers.

In areas escaping damage and continuously developing towards the stage of grass patch and Cyperaceae plants, the better herbages increase in quantity and supply O. curzoniae with ample food. The small animals move in and destroy the vegetation. The endless damage causes the old fields to be difficult to restore.

Key words: re-vegetation, rodent damage, Ochotona curzoniae, Myospalax fontanieri.

5-3-1

Savanna Ecosystems in Tropical America: Findings from a Computerized Land Resource Survey

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A land resource survey modeled on the Australian land systems approach was started in mid-1977 to study the acid, infertile soil regions of Tropical America, with the objective of creating a base for the development and transfer of improved germplasm based technology for pasture production. Preference was given to study the 200 million hectares of native savannas, although the survey now stretches across the Amazon forests to Southern Brazil.

The study reduces land information to a common base in terms of land systems defined as repetitive patterns of climate, landscape and soils. These are delineated directly onto satellite and side-looking radar imagery following field work and climatic analyses. Within land systems the vegetation and soils are separately described and estimated according to their occurrence on landscape facets that follow the principal topographic, vegetation and soil sequences within the land systems. Following the collection of the land resource information, it is recorded in a computerized data storage, retrieval and analytical, map and data printout system to facilitate speedy and comprehensive analyses.

The geographical distribution of the savannas is summarized from thematic map printouts. They separate on the basis of soil drainage into poorly drained and well drained savannas. Both categories are widely distributed throughout the subcontinent, although the well drained savannas are three times more extensive.

In spite of their disperse geographical distribution, it was found that the well drained savannas occupy a well defined habitat delimited by the climatic potential for growth; they can be discriminated from other physiognomic vegetation classes on the basis of total wet season potential evapotranspiration. Within these savannas there is no significant difference in the mean total wet season potential evapotranspiration between groups with 6, 7 or 8 months of wet season. However, wet season mean monthly temperatures effectively separate lowland from higher land savannas.

Following from the comparison of savanna climates, the landscape and soil features were described and compared. The well drained savanna soils are mainly Oxisols, Entisols and Alfisols. Oxisols predominate; their fertility status is generally very poor. Fertility gradients do not follow relative arboreal biomass contents.

Finally, the implications of the findings of the survey are discussed in terms of their contribution to the development of improved germplasm-based pasture technology, to help increase cattle production in the savannas of Tropical America.

Key words: savannas, potential evapotranspiration, land systems, Oxisols, land resource survey, Tropical America.

5-3-2 A System of Grassland Classification in Synthetic Order and Its Key Chart of Classes

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Based on the dynamic theory of grassland genesis, the authors presented a system of grassland classification in synthetic order, climate-land-vegetation.

The first grade "class" is an elementary unit of classification. It is determined by the distributive features of moisture-heat quantity. Classes may be combined into "groups" on the basis of the same heat quantity or humidity.

The second grade "subclass" is divided within the class according to the land (soil and topography) characters, which might be used as indicators of land utilization.

The third grade "type" is divided within the subclass according to the vegetation. The same "type" of rangeland indicates the feed value and the practical techniques hereof would be similar. The "type" may be further divided into "subtype" and "microtype."

The system of grassland classification in synthetic order is used in such a way as to divide rangelands into classes on the basis of bio-climatic factors -- moisture and heat condition. the annual accumulated temperature at degrees centigrade above zero (ΣΘ) is used to determine the warm conditions, being classified into eight grades. Moisture is determined by the "Grade of Moisture Index" (GMI) "K." There are six grades of GMI in China.

Using annual precipitation (r) as abscissa and annual accumulated temperature above zero (^{o}C) as ordinate, the "key chart of grassland classification" is compiled. Sites where accumulated temperature above zero (^{o}C) and annual rainfall intersect may be found in the key chart, so the "class" of a site is identified.

Key words: system, classification, synthetic, classes, subclasses, type, chart, index.

5-3-3 Forest Range Evaluation in Southeastern United States

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The goal of the Southern Evaluation Project is to promote sound multiple-use management of the southern forested lands. In order to achieve this goal, four major objectives were selected:

1. Develop and test quantifiable resource management techniques to improve management predictability and guidelines.
2. Evaluate impacts of timber, wildlife, and range management alternatives from a biological, physical, economic, and social standpoint.
3. Provide technology transfer to land owners and managers, both private and public.
4. Demonstrate selected management levels on an operational scale.

This project was developed using three phases:

1. Pretreatment: 1978-81--Select study areas, make pretreatment baseline inventory measurements and provide some facilities, such as perimeter fences.
2. Treatment: 1982-83--Provide additional facilities and initiate range, timber, and wildlife management treatments on the study areas.
3. Post Treatment: 1984-88--Administer management of treatments, make measure of responses and provide technology transfer through demonstration and publication.

This information will provide direction for the multiple-use forest range program in the South. Two areas, of about 8,000 acres each, located in Texas and Louisiana represent the loblolly-shortleaf pine type. Three areas in Louisiana, Mississippi, and Florida provide the longleaf-slash pine type. Research, training, coordination, and extension activities will bring the project to a point of practical application to fully utilize the results of the study.

To date, more than 30 studies on the five areas have been initiated through cooperative agreements among state, private, and federal organizations. The pretreatment phase for biological and physical measurements is presently underway with some preliminary results available. For instance, on the Mississippi location 12 types of mid- and large-sized mammals were recorded through sightings and track counts, a total of 447 small mammals representing 10 species were trapped in about 10,000 trap-station nights, 72 birds were recorded from May through January, and 14 species of amphibians and 22 species of reptiles were recorded in March and June. Order 2 soil surveys and taxonomic soil descriptions are now complete and 2 years of timber, mid-story, herbage and browse measurements are complete for all but one area. Results of the pretreatment measurements reflect present land management and provide baseline data for future assessments. Social (beauty, recreation, rural development, etc.) and economic (cost, returns, employment, etc.) measurements are being designed for treatment evaluation.

Key words: management, demonstration, social, economic, biological, timber, wildlife, livestock, forage, range.

5-3-4 Frost Heaving and Production of Alfalfa on Soils with Different Drainage Characteristics

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Establishment and maintenance of good alfalfa (Medicago sativa L.) stands are serious problems in the climatic-transition zone of the Central United States because of frost heaving. Many soils in this zone have impermeable subsurface layers which form perched water tables during much of the winter. These conditions, combined with fluctuating temperatures above and below freezing, may subject these soils to severe alfalfa frost heaving. The objectives of this study were to evaluate the effects of frost heaving action on establishment, persistence, and productivity of selected alfalfa cultivars in relation to soil drainage characteristics.

This study was conducted on three sites with different soil drainage characteristics in southern Illinois from 1975-1980. Field plots of four alfalfa cultivars ('Cody', 'Spredor', 'Weevlchek', and WL-307) were seeded in Sept. 1975 on poorly drained Weir (fine, montmorillonitic, mesic Typic Ochraquaif), a moderately well-drained Hosmer (fine-silty, mixed mesic Typic Fragiudalf), and a well-drained Alford (fine-silty, mixed mesic Typic Hapludalf). A randomized complete block design with four replications of each cultivar on each soil series was employed. Piezometers were installed to the impermeable soil layer to measure perched water table positions during the winter. Stand evaluations, plant heave, and dry matter yields were ascertained each year.

The nearer the perched water table was to the soil surface, the greater the degree of alfalfa frost heaving and winterkill. The poorly drained Weir had a perched water table at or near the soil surface resulting in the greatest alfalfa seedling heave and winterkill. Well-drained Alford soil had little or no perched water table, thus no appreciable seedling heave or winterkill. No notable differences in frost heaving were found among alfalfa cultivars in establishment. Soil drainage characteristics also influenced alfalfa persistence and production. There was a positive correlation between height of alfalfa heave and number of plants dying. The higher the seedlings heaved, the greater was the seedling mortality. Seedlings usually died if they heaved more than 50 mm. Significant differences were found in yields among alfalfa cultivars within and among soil drainage classes.

The selection of a well-drained soil site is an important consideration for good alfalfa establishment, persistence and production. However, moderately well-drained soils may be used for alfalfa production when well-drained soils are unavailable in the climatic transition zone of the Central United States.

Key words: alfalfa, Medicago sativa L., frost heaving, piezometers, soil drainage classes, soil water tables, winterkill.

5-3-5

Hail as an Ecological Factor in the Increase of Pricklypear Cactus

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Detached joints or pads of plains pricklypear cactus (Opuntia polyacantha) can root and form new plants. However, few data exist to quantify this phenomenon or to describe conditions under which rooting takes place. A severe hailstorm at the Central Plains Experimental Range in northeastern Colorado, U.S.A., on July 31, 1978 broke segments from plants of plains pricklypear. This provided an opportunity to determine the amount of joint dispersal and rooting from a natural destructive event.

Cactus joints detached and scattered by the force of the hail were counted on permanent belt transects established in exclosures and adjacent grazed areas in 2 pastures having different pricklypear populations. One year later, the transects were sampled again to determine the number and proportion of joints that had successfully rooted and become established.

Precipitation after the hailstorm in 1978 and the first 4 months of 1979 was less than 100 mm (67% of the long-term average). Some joints had short roots on the underside by late winter of 1978-79, but no roots reaching the soil were found in April. In May and June, more than 200 mm of precipitation fell, almost twice the average for that period.

In one pasture, where the average ground cover of pricklypear was approximately 1.2%, the hail detached 4100 cactus segments/ha. In the other pasture, pricklypear had an average of 3.8% ground cover and hail detached 25,300 segments/ha. In the pasture with the least pricklypear, 34% of the segments had rooted by August 1979, while only 13% of the segments had rooted in the other pasture. However, the population of rooted segments was equivalent to 1400 and 2400 new plants/ha in the pastures with the least and most pricklypear respectively. Thus, more potential new plants were established in the pasture that already had the most pricklypear even though a lower percentage of the joints had rooted. There was no consistent difference in rooting success between the exclosures and the grazed areas in either pasture.

The detached pricklypear joints that eventually rooted, survived 9 months of unfavorable moisture conditions and then were able to successfully root after moisture became available. This remarkable adaptivity may be one of the reasons why pricklypear is so prevalent and persistent on the Great Plains.

Key words: Opuntia, pricklypear, hail, roots, control, re-establishment, drought, precipitation, ecology.

5-4-1

Nutritional Quality of Leaf Proteins Prepared from Crops Containing Phenolic Compounds and Polyphenolase

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Many studies have indicated that leaf protein prepared by green crop fractionation affords good potential as a protein supplement. It has been noted, however, that there were some marked differences between crops in the nutritional quality of leaf protein in spite of a similarity in amino acid composition between leaf proteins made from different crops.

We previously showed that brown-coloured casein which was produced by the interaction of milk casein with phenolics undergoing enzymic oxidation had lower nutritional value than original casein. In addition, it has been suggested that leaf proteins prepared from crops containing phenolics and polyphenolase were brown-coloured after extraction with acetone. It can therefore be presumed that the browning of leaf protein brings about the lowering of its nutritional quality. The object of this report is to determine whether the browning of leaf protein affects its nutritional quality.

Italian ryegrass, red clover, sorghum and alfalfa were used for leaf protein preparation. Fresh leaves were pulped in the presence or absence of a reducing agent; sodium ascorbate or $NaHSO_3$, and green juice was separated. Protein was coagulated by adjusting the pH of the juice to 4, followed by heating and then washed with acetone. The biological evaluation of leaf proteins was carried out by the growth method with male rats weighing about 50g.

Italian ryegrass, red clover and sorghum had o-diphenolic contents and polyphenolase activity. The leaf proteins from Italian ryegrass, red clover and sorghum were brown-coloured when leaves were pulped in the absence of a reducing agent. On the other hand, alfalfa had neither o-diphenolics nor polyphenolase, and hence the browning of alfalfa leaf protein did not occure even in the absence of a reducing agent during pulping. The brown-coloured leaf protein from Italian ryegrass had lower digestibility than the leaf protein protected from browning although there were no differences in growth-promoting effect and protein efficiency ratio (PER) between the two leaf proteins. The feeding of brown-coloured leaf protein from red clover resulted in the lowering of weight gain, digestibility and PER, and all the measurements including diet intake were lowered by feeding the brown-coloured leaf protein from sorghum. In the case of alfalfa leaf protein, there was no difference in nutritional quality between the two leaf proteins made with and without attempt to prevent browning.

The results mentioned above indicate that the occurrence of phenolics and polyphenolase in a crop is responsible for the browning of leaf protein and that the browning of leaf protein causes its nutritional impairment.

Key words: leaf protein, diphenolic compound, polyphenolase, browning, Italian ryegrass, red clover, sorghum, alfalfa.

5-4-2

Evaluation of Biological Components in Decision Making in Forage Allocation

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We consider the problem of forage allocation to mixtures of large herbivores by minimizing the difference between the available herbage and the required forage for animals on the rangeland. Availability is determined in part by the plant's physiological tolerance to grazing or its allowable use factor, and its relative preference (measured in part by the proper use factor) to the mix of large herbivores grazing the range. The grazing requirements for animals are dependent on plant species preference and on the total forage intake rates. This paper critically analyzes these concepts and published information and data. The concept of proper use factor is widespread, but the published methodologies for proper use factor formulation are lacking. Allowable use factors, determined primarily in clipping studies, are generally higher than proper use factors, but the exact relationship between proper use factors and allowable use factors is unclear at best. Preference of plants, as used in the literature, varies in meaning from percentage eaten by forage class (grasses, forbs, and shrubs) to rankings of percent of plant species in herbivore diets to actual calculation of a preference index. The method used to calculate a preference measure can yield varying results and interpretations. Forage intake rate studies which use animals under grazing rather than pen conditions appear to be confined to domestic sheep and cattle. Some 52 intake rate values for cattle yielded results of 7.5 kg/animal/day. Some 53 intake rate values for sheep resulted in 1.4 kg/animal/day. We also report forage intake rates for pronghorn antelope, bison, bighorn sheep, mule deer, horses, burros, and elk. Through understanding these variables, effective management strategies may be derived whereby the rangeland resource can be used prudently without degradation.

Key words: forage intake rate, preference, proper use factors, forage allocation, optimization.

5-4-3 Evaluation of Sewage Sludge Fertilization of Pastures for Beef Cattle

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Increased environmental awareness by citizens and government demand that municipal waste disposal be environmentally safe. Because municipal sludges are high in both N and P they offer great promise when recycled onto agricultural land. Sludge disposal must be done on a regular basis year-round. Pastures offer greater flexibility than most crops in terms of application time. The amounts that can be safely and profitably applied to pastures were the primary concern of this research. Specific objectives were to measure: (1) forage yield and quality; (2) animal performance; and (3) heavy metal accumulation in plant and animal tissue when liquid sewage was applied to pastures.

Angus cows with nursing calves and Angus steers were grazed for 130 days on tall fescue (Festuca arundinacea Schreb.) pastures treated with: (1) NH_4NO_3 applied 21 days before grazing; (2) liquid sewage sludge applied 21 days before grazing; and (3) liquid sewage sludge applied one day before grazing. Rates were adjusted to apply equal amounts of plant available N to each treatment. Pastures were grazed in a 4-paddock rotational system (7 days grazing and 21 days regrowth). Forage yields before and after each grazing, animal performance, pathologic lesions, parasite levels, viral infection, and heavy metal residues in tissues were measured.

Excellent forage growth resulted from liquid sludge application. Forage quality, as measured by crude protein and IVDMD was similar for all pasture treatments. Forage acceptability was good on all pastures except those sprayed with sludge one day before grazing. Spray-applied sludge adhered to the foliage and was a major source of metal consumption by the grazing animal; direct consumption of liquid sludge from the soil surface also occurred. Parasite ova in feces were within the normal range and virus isolations appeared to be associated more with animal stress than with pasture treatment per se. Initially, animal performance was similar on the NH_4NO_3 and day-21 sludge pastures; however, by the end of the grazing season performance was markedly reduced on both day-21 and day-1 sludge-treated pastures. Weight losses were greatest for the cows with nursing calves grazing on day-1, sludge-treated pastures. The liquid sludge was especially high in iron (average of 11% for the season) and significant amounts of ferritin accumulated in the duodenum, lymph nodes, liver, kidney, and spleen. Other metal accumulations occurred but they were not significant. While dietary Cd was substantially increased by sludge applications (5-10 ppm Cd), kidney Cd was not significantly increased. Indications are that iron accumulations resulted in either iron-toxicity or possibly iron induced copper-deficiency. In subsequent studies with lower iron sludges we did not observe similar animal performance problems, nor excessive iron accumulation.

Key words: Festuca arundinacea, forage acceptability, toxicity, iron, cadmium, heavy metals, parasites, virus.

5-4-4 Evaluation of Pastures in the Desertic Zone of Venezuela for the Development of Goat Production

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The desertic zone of Venezuela is an area of approximately 4.1 million hectares, 4.75% of the total national territory, where there are two million goats. Goats represent the main, if not the only, income source for some 60,000 rural families.

This paper is a review of the work done by Gallardo and Leone at El Cuji Experimental Station, located in Barquisimeto, State of Lara, Venezuela.

According to UNESCO, 1973, the desertic zone of the country comprises two vegetation types: evergreen scrub and deciduous scrub. In each of these zones the plant species used by the goats were collected and, for those plant parts consumed by the animals, a bromatological analysis was made to determine nutritive value. Forage plants from other tropical countries were also introduced and evaluated.

Studies done on natural vegetation show that various species have a high crude protein content. Outstanding among these were Acacia flexuosa (21.7%), Prosopis juliflora (27.8%), Setaria macrostachya (13.5%), Sporobolus pyramidalis (16.4%), Lippia alba (11.2%) Lippia origanoides (22.0%), Malpighia glabra (23.2%) and Wedelia caracasana (18.7%).

Previous work at El Cuji Experimental Station, where we have been introducing and evaluating forage and browse species, permitted us to select the most promising ones, such as: Panicum coloratum (Bambatsii), Cenchrus ciliaris (Malopo, Gayndah, Biloela), Cynodon dactylon (SR-954, Gigante), Pennisetum purpureum (Taiwan A-146, Mineiro), Glycine javanica and Leucaena leucocephala.

In conclusion, this study represents a valuable guide for managing vegetation towards desirable forage associations and, at the same time, it offers alternatives towards repopulation of these areas with species of high nutritive value which could contribute to a better exploitation of goats.

Key words: arid grasses, palatability, goats, dry matter, protein content.

5-4-5 Sward Composition and Animal Output from Grass on Commercial Farms

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The objective was to assess the Utilized Metabolizable Energy (UME) output derived from grass on a wide range of farms, and to relate this output to environmental differences between farms, age and composition of swards, and technical inputs.

A sample of 330 predominantly grass farms in England and Wales was studied; 153 were dairy farms and the remainder were beef farms, many of which had substantial sheep flocks. The farms were visited regularly for two consecutive years to collect livestock and field management records. All fields were surveyed to describe topography, soil, sward age and botanical composition. Swards were classified according to the contribution to ground cover of 'sown' species, i.e. those grasses and legumes usually included in seeds mixtures in the U.K. (chiefly Lolium perenne and Trifolium repens).

Comparison with other published data showed that the farms were quite typical of grassland in the country as a whole. Botanical composition was very variable in swards of all ages, but on average sown species contributed about 60% of the cover in swards under 20 years old and 30% in older swards. (The remainder was made up largely of indigenous grasses e.g. Agrostis, Poa and Holcus). The proportion of sown species was also significantly correlated with fertilizer N input.

An average sown species content was calculated for each farm, and the farms ranked accordingly. The upper quarter of dairy farms averaged 68% sown species, the lower quarter only 30%; but the difference between their UME outputs (45 and 40 GJ ha^{-1} respectively) was no greater than could be expected from the different inputs of fertilizer N (185 and 115 kg ha^{-1}). Among suckler beef farms, the corresponding sown species contents were 56% and 19%; but the difference in UME output (45 cf 28 GJ ha^{-1}) was much larger than that recorded for dairy farms, and larger than could be accounted for by the difference in N input (67 cf 27 kg ha^{-1}).

We conclude that on beef farms, which represent a very wide range of environments and on which average inputs of fertilizer N are relatively low, botanical composition of swards is a good indicator of productivity; farms with Lolium-dominant swards achieve significantly higher outputs. This does not necessarily mean that botanical composition is a prime cause of differences in output. On dairy farms there is little evidence of a direct benefit in utilized output from grass resulting from the presence of a high proportion of sown species in swards. The need for deliberate manipulation of botanical composition, by reseeding or other means, must therefore be questioned.

Key words: sward composition, Lolium, utilized output, farms, reseeding.

5-5-1

Grassland Development in the Southern Highlands of Peru

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This paper describes grassland development in Peru. The high alpine region which occupies 4.000,000 hectares in Peru has a vegetation dominated by low producing native grasses normally producing less than 2000 kg/ha dry matter annually. Very little rain normally falls from March to October, resulting in acute shortages of forage during the dry winter and spring.

An estimated 3 million people, the majority subsistence farming, are largely dependent on agriculture. Intensive development of the unimproved pastures offers one means of greatly increasing agricultural production.

A NZ team has been involved in a pasture improvement program in Peru since 1974. Prior to that time less than 40 ha of improved pasture had been sown in the southern highlands. Since 1974, 2000 ha of improved pastures and alfalfa (Medicago sativa L.) have been sown, as well as annual sowings of 800 ha of forage turnips (Brassica rapa L.).

Permanent high producing pastures based on perennial ryegrass (Lolium perenne L.) and white clover (Trifolium repens L.) have been successfully established on land with adequate soil moisture.

These pastures rely almost entirely on the legume component to provide nitrogen and on most soils phosphate is the only fertilizer required. On drier sites alfalfa has proved the most successful legume, producing over 12000 kg/ha/yr in some trials.

Alfalfa and clovers have been successfully introduced into unimproved native pastures by mechanical direct seeding and by hand sowing. With direct seeding dry matter production increased from about 600 to 6000 kg/ha in 2 years and to more than 10,000 kg/ha in older swards.

Innoculation of legumes proved essential. The effectiveness of the innoculants was enhanced by increasing the rate of innoculant, use of lime innoculated and pelleted seed or by sowing 500 kg/ha lime with the seed.

Excellent results were obtained from sowing NZ turnips, 8-10,000 kg dry matter being produced in 5-6 months. NZ forage oats (Avena sativa L.) and ryecorn (Secale cereale L.) produced 8-16,000 kg/ha and showed improved frost tolerance compared with local cultivars.

This program indicated grass/clover pastures and alfalfa can be successfully established in the Peruvian highlands. Production increases up to 10 fold have been obtained and animal carrying capacity and performance increased accordingly.

Key words: grassland development, high alpine, Peru, alfalfa (Medicago sativa L.), white clover (Trifolium repens L.), innoculation, lime, pelleting, phosphate, forage crops.

5-5-2 Effects of Continuous and Deferred-Rotation Grazing on Mountain Riparian Vegetation and Water Quality

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Riparian habitat is a focus for concern in the management of western rangelands. The problem was created by the deterioration of and increasing demands for this limited resource. In order to meet these multiple-use demands, holistic approaches to management must be developed to preserve, maintain and improve riparian ecosystems. For this reason, it is important to determine the effects of present management systems.

This study was designed to evaluate continuous season-long and deferred-rotation cattle grazing on a high mountain watershed. The effects of these grazing systems were compared in terms of vegetation composition and water quality. The riparian zone was stratified into vegetation associations and monitored to indicate levels of nutrient enrichment and fecal pollution in two stream systems. Fecal coliforms, fecal streptococci, total count and fluorescent colonies were enumerated weekly during spring runoff and twice monthly during the grazing season.

The composition of vegetation associations indicated a drier moisture regime under continuous grazing. On the subirrigated meadows, the percent grasses was 38% higher under deferred-rotation grazing. Tufted hairgrass (Deschampsia caespitosa) and fowl bluegrass (Poa palustris) were notable decreasers under continuous grazing. Wetland meadows were less sensitive to grazing pressure, but exhibited a slight trend toward a decrease in sedges and an increase in grasses under continuous grazing. Analysis of moisture zones showed no significant differences in the percent of the valley floor that was wetland or subirrigated. Subirrigated meadows provided the most desirable forage and were the most sensitive to grazing pressure. A more palatable and digestible forage was available under deferred-rotation grazing with a higher percentage composition of grasses and succulent forbs. Subirrigated grazing zones should receive special attention in the development, implementation and monitoring or management of riparian habitat.

Bacterial counts exhibited significant differences for some groups between grazing treatments for each stream. However, these differences were expressed as higher counts on the continuous allotment in one stream and as higher counts on the deferred-rotation allotment in the other stream. A significant difference between streams was indicated during the grazing season of 1979 for all indicator groups.

The apparent contradictions in bacterial responses may be explained by differences between streams and treatments in the number of beaver ponds. For the stream with approximately equal water impoundment for both grazing treatments, deferred-rotation grazing benefited water quality with significantly lower bacterial counts. The other stream system with much greater water impoundment showed significantly lower counts on the continuous allotment. This stream under continuous grazing had a greater number of beaver ponds than under deferred-rotation grazing. Beaver ponds benefited water quality by filtration and settling of organisms in water.

Key words: Grazing systems, cattle, riparian, water quality, beaver.

5-5-3

Interception of Rainfall by Creosotebush (*Larrea tridentata*)

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The objective of this study was to examine interception by creosotebush (*Larrea tridentata* [DC.] Cov.) of artificially applied rainfall for improved understanding of this phenomenon in hydrologic processes. This research was conducted near Las Cruces in southern New Mexico. Forty-four creosotebush shrubs were collected to obtain a representative sample of shrub size classes. Simulated rainfall was applied at the rate of 6 cm/hr. Measurements taken on each shrub were: 1) shrub height, 2) canopy area, 3) shrub volume, 4) number of stems, 5) leaf area, 6) green weight of stems, 7) oven-dry weight of stems, 8) green weight of leaves, 9) oven-dry weight of leaves, and 10) shrub green weight. Shrub height and the maximum and minimum diameter of the crown canopy were measured for determining canopy cover and shrub volume. The shrubs were severed at the base of the stem, weighed, and placed in a metal holding device. Shrub weight was again taken after 30 minutes of simulated rainfall and the difference in weight recorded as the amount of rainfall that was intercepted. Canopy cover of the creosotebush community was determined from 10 30.48 meter (100 ft.) line transects. A stepwise regression analysis was performed on the data to determine from the collection of independent variables which have the best relationship to the dependent response variable. It was determined that leaf area was most highly correlated with rainfall interception followed by the number of stems, crown canopy area, and the weight of the oven-dry leaves. The average interception capacity of the 44 creosotebush shrubs was 1.2 gms/cm^2 expressed in grams of water held per unit area of crown canopy. The average leaf area per shrub including both sides of the leaves was 10576 cm^2. Expressing the amount of water intercepted as a function of leaf area shows 0.54 gms/cm^2. The annual rainfall in the southwestern United States is produced from storms of small amounts. Thus interception by desert shrubs is of significant importance since a high percentage of precipitation from these storms is "lost" due to interception and subsequently evaporated back into the atmosphere. Forty percent of the artificially applied rainfall was intercepted by creosotebush. For the native stands of creosotebush that had 30 percent crown cover the loss of rainfall by interception would equal 12 percent. This clearly demonstrates that light showers do little to replenish soil water.

Key words: interception, creosotebush, *Larrea tridentata* (DC.) Cov.

5-5-4 Utilization of Hydromorphic and Alkaline Hydromorphic Soils in Sap Vojvodina by Establishing Cultivated Grassland

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Hydromorphic and alkaline hydromorphic soils are heavy and unsuitable for the growing of row crops. Such soils have poor structure and water-air properties rendering the cultivation expensive. The establishment of cultivated grasslands and the production of fodder lasts for 4-5 years, requiring smaller expenses than those necessary for the production of row crops.

Four-year experiments, conducted on hydromorphic and alkaline hydromorphic soils, included four varieties of grasses and three varieties of legumes. Yields, chemical composition of hay, and effects on some physical-chemical composition of hay and soil properties were examined.

The results obtained indicated that cultivated grasslands are a rational form of utilization of swampy areas for the production of fodder. Dactylis glomerata L., Arrhenatherum elatius L. with Medicago sativa L. and Lotus corniculatus L. showed the best performance . Festuca pratensis Huds., especially L. corniculatus L., showed the best reaction to the occurrence of surface water for the period of 4-6 weeks. Birdsfoot trefoil was the most resistant to drought. Average annual hay yields were 81.0-89.89 q/ha on hydromorphic soil and 97.20-104.20 q/ha on alkaline hydromorphic soil. The biggest respective yields were 126.2 and 132.7 q/ha. The overall average was 109.33 q/ha.

Cultivated grasslands improve physical and chemical properties of the examined soil types, especially their structure and water-air properties, securing a more successful cultivation of row crops in rotation.

The agrophytocenoses of grassland type are a form of long-term land use. They regenerate well as confirmed by 3-4 cuttings of excellent fodder yearly, crude proteins content of 16-17% and good digestibility.

Cultivated grasslands on hydromorphic and alkaline hydromorphic soils not only secure the production of fodder and improve physical-chemical soil properties but also become an important anthropoecological factor in the improvement of human environment.

Key words: hydromorphic and alkaline hydromorphic black soils, problems of utilization, cultivated grasslands, fodder.

5-5-5 Simple Mixtures for Dry Mountain Regions: Relations Between Tall Fescue and Birdsfoot Trefoil

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Grass-legume mixtures are of great interest, especially for the central and northern Appennines with a summer dry season. Birdsfoot trefoil (Lotus corniculatus L. cv. Franco) and tall fescue (Festuca arundinacea Schreb. cv. Manade) were used in mixture and in pure stand at the experimental farm of the Institute. Our objectives were to fix the seeding rates in mixtures of birdsfoot trefoil and tall fescue, with particular attention to the more suitable method of sowing.

The two species were seeded in mixture and alone to 20 seeding treatments, as follows:

a) 16 mixtures in alternate rows of 12 cm, given by factorial combination of four different seeding rates (5-10-12-15 Kg/ha of birdsfoot trefoil and 5-7-10-15 Kg/ha of tall fescue).

b) 1 mixture of the blended two species 1:1 at the highest seeding rates (15 Kg/ha), in rows of 12 cm.

c) 3 pure stands, 1 of birdsfoot trefoil (15 Kg/ha) and 2 of tall fescue (15 and 30 Kg/ha), in rows of 12 cm.

The experimental layout consisted of a randomized block with four replicates giving 80 experimental units, each measuring 2.4 m^2. The trial was carried out during five years (1975-79) without irrigation. The harvest of each cut was dried (105°C) and weighed; yields of mixtures were parted into their components.

Analysis of the collected data demonstrated:

1) a significantly (5% level of probability) higher yield of the mixtures when compared to pure stands of the two species (61% average percentage of the legume in the establishment year and 10% in the fifth year); and

2) significant prevalence of the mixture seeded in blend over all the 16 treatments of mixture in alternate rows (54% being the percentage of birdsfoot trefoil in the establishment year and 14% in the fifth year).

Mixtures of birdsfoot trefoil and tall fescue were shown to be very significant not only because of their high yielding but also for the quality of forage. The presence of the two different species secured a bulk of good fodder, and stability of production as well, during the vegetative season.

Key words: mixture, pure stand, birdsfoot trefoil, Lotus corniculatus L., tall fescue, Festuca arundinacea Schreb.

6-1-1

Strategies of Warm-Season Grass Seedling Development

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Establishment of warm-season prairie grasses is often difficult because of slow seedling growth and weed competition. Research was undertaken to compare seedling development of four perennial warm-season grasses with that of a vigorous annual grass, giant foxtail (Setaria faberi Herrm.).

Big bluestem (Andropogon gerardii Vitman), switchgrass (Panicum virgatum L.) indiangrass [Sorghastrum nutans (L.) Nash], caucasian bluestem [Bothriochloa caucasica (Prin.) C.E. Hubb] and giant foxtail were germinated on filter paper and transplanted to a greenhouse. Leaf extension rate, collaring date and leaf length were measured daily. Carbon exchange rate (CER) was determined. Plants were harvested at two morphological stages,and yield components, leaf area and tiller numbers were recorded.

Giant foxtail, the most vigorous seedling, had a very rapid leaf extension rate, developed quickly and allocated a major portion of its assimilates to the above ground portion of the main shoot. Very little tillering occurred up to the 8th collared leaf stage. Big bluestem and caucasian bluestem developed nearly as quickly as giant foxtail but the leaf extension rate was much slower, leaves were shorter, so much less photosynthetic area was present at any morphological stage. Caucasian bluestem produced a large number of tillers at an early morphological stage and, although small, additional photosynthetic area was developed. Big bluestem allocated more of its assimilates to the root system and did not tiller as much as caucasian bluestem. Switchgrass and indiangrass developed much more slowly than the other grasses and took longer to reach the 6th and 8th leaf stages. Once they reached the 4-leaf stage their leaf expansion rate was intermediate between giant foxtail and caucasian or big bluestems. Switchgrass tillered more th[illegible] big bluestem. Carbon exchange rate was lower for giant foxtail and caucasian bluestem than for the other grasses.

In a breeding program selecting for rapid leaf elongation rate in caucasian bluestem and big bluestem could result in greater seedling vigor since more photosynthetic area would be produced early. Switchgrass and indiangrass selected for rapid development prior to the 4-leaf stage with the same or greater leaf extension rate that occurs later in their development could result in greater seedling vigor. Selecting for CER in a warm-season grass breeding program probably would not result in greater seedling vigor.

Key words: Andropogon gerardii Vitman, Sorghastrum nutans (L.) Nash, Panicum virgatum L., Bothriochloa caucasica (Prin.) C. E. Hubb., Setaria faberi Herrm., leaf growth, tillering, carbon exchange rate.

6-1-2 Flowering, Seed Formation and Juvenility in *Stylosanthes guianensis*: the Effect of Climatic Factors

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1. Stylo (*Stylosanthes guianensis* var. *guianensis*) is a tropical pasture legume with a short-day (SD) flowering response in which selections show variation in the minimum length of photoperiod required for flowering. Evidence was encountered that the SD response is modified variously by temperature in different selections. This interaction was then studied with respect to (1) the passage of the juvenile period before plants respond to SD cycles, (2) time of floral initiation (FI) and (3) the flower appearance (FA), (4) inflorescence differentiation and (5) seed formation.

2. Stylo selections were grown on the island of Bali at similar latitudes (c. 8° 30'S) at altitudes of 10, 285, and 1000 m and also in controlled environment cabinets and glasshouses.

3. Selection variation in the length of the juvenile period and in the effects of day and night temperatures on the passage of juvenility is described.

FI at the cool high-altitude site was earlier in cv Schofield and cv Endeavour, and later in CPI 34906, than at the warmer low altitudes; time of FI in cv Graham and cv Cook was independent of site. Mean temperatures during the period of FI in cv Schofield were 23.2, 24.6 and 26.6°C at the three sites, where FI date varied by 84 days. Flowering of cv Schofield was incomplete at low altitude. Cool temperature promotion of FI in cv Schofield also occurred in 12-hr day cabinets at 18° and 21° relative to 24° and 27°C.

The duration of the phase from FI to FA was usually (but not invariably) related negatively to temperature. In cabinets days from seedling emergence to FA (y) in cv Cook was related to temperature (x) over the range 18 to 27°C by the function $y = 438-22.3x + 0.38x^2$, emergence to FA in cv Schofield was little influenced by temperature, because of the opposing effects of temperature on the early and late stages of development.

Inflorescence density was maximal at 24°C in cv Cook and cv Endeavour. In the field, low inflorescence density in cv Graham and cv Endeavour at the highest site was allied with enhanced floret number per inflorescence. However, cool temperatures delayed floret maturity and increased floret abortion.

Seed yields in the field were sensitive to weather during ripening; the highest seed yields were obtained from cv Endeavour (1660 kg ha^{-1}) and cv Graham (1090 kg ha^{-1}) at the lowest Bali site.

4. An understanding of the climatic controls of flowering and seed formation helps to define the districts in which plant replacement from soil seed reserves may occur or which are suited to seed multiplication. Cool temperatures promote the flowering of cv Schofield in equatorial latitudes where day length is otherwise marginal for flowering, but these inhibit the flowering of other selections such as CPI 34906. The cultivars Graham, Cook, and Endeavour are adapted to a wider range of environments.

Key words: stylo, *Stylosarthes guianensis*, flowering, photoperiod, temperature, juvenility.

6-1-3 Climatic Influences During Flowering on Seed Dormancy and Seed Formation of Stylosanthes hamata cv. Verano

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Effects of variation in temperature, soil moisture supply and illuminance on the seed dormancy and seed formation of *Stylosanthes hamata* cv. Verano were studied.

Plants were grown in the open in successive seasons, in controlled temperature cabinets, and in the glasshouse where shading and watering treatments were varied after the onset of flowering.

Hardseededness was strongly developed and was positively related to the temperature during seed formation. Seed moisture content was the main factor governing hardseededness after seed maturation, and this was negatively associated with temperature during seed formation. High levels of hardseededness developed in all seeds when seed moisture content was below c. 7 per cent, but the equilibrium moisture content of seeds stored in atmospheres of varying relative humidity was modified by temperature during seed formation. This helps to explain variation in hardseededness due to the differing provenance of seed lots.

Seeds formed under high temperature had higher contents of lignin (which was concentrated in the counter palisade cells) and of hemicellulose, lower contents of cellulose, and shorter palisade cells; cutin content was independent of temperature. The seed coat of hard seeds exhibited a more regular and organise structure and a more evenly reticulate surface than that of soft seeds. Seed colour changed from dark to light as temperature of seed formation decreased from 27° to 21°C, but hardseededness was found to be unrelated to seed colour per se.

Embryo dormancy was transitory and little developed. An inhibitor in the pod or testa restricted germination; this was independent of climatic conditions during seed formation and decreased after 120 days of seed storage. Dormancy was more strongly developed in the hooked upper articulation than in the lower hookless articulation.

Short durations of soil moisture stress which reduced leaf water potential to minimum values of c. -25 to -28 bars, and shading treatments which reduced illuminance to c. 20 per cent of full daylight reduced seed production, but hardseededness was not consistently related to these treatments.

Time of blooming, rate of floret appearance, total floret differentiation, duration of flowering, floret abortion, lower articulation formation and time to pod maturity were sensitive to temperature conditions. Seed yield was maximal at 31/24°C.

S. hamata cv. Verano is a short-lived plant, and the persistence of yield depends upon continual plant replacement from soil seed reserves. The level of seed production and of hardseededness are increased by warm conditions during flowering, and this factor favours and may even restrict its adaptation to dry tropical environments.

Key words: Stylosanthes hamata, Verano, seed dormancy, climate temperature.

6-1-4 Peculiarities of Tiller Formation of Perennial Panicoides and Eragrostoides

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The main aim of the work was to systematize the data on tiller formation in perennial Panicoides and Eragrostoides with the subsequent substantiation of the peculiarities of the uses of separate species and vital forms. Objectives of the work were: to study tillering and branching; to order the data according to tiller formation; and to classify the vital forms of tropical grasses according to their evolutionary important characters and rational use.

For 18 years we studied tiller formation and vital forms of tropical grasses of the flora species found in the southern regions of the USSR (10 species) and in Cuba (about 80 species) using herbarium of East Africa and the Pacific Islands as well as literature data. Observations were taken regularly in stationary sown areas and periodically under natural conditions by collecting plants in certain vegetative stages with subsequent morphological and in some cases anatomical, biochemical and physiological analyses.

Transition of plants into tillering is accompanied by a high degree of dry matter accumulation, activation of nitrogen (protein) metabolism; phosphorus (particularly organic) accumulation in tissues; increase in respiration and photosynthetic rates, etc. Similar tendencies were observed during vegetative reproduction as well. Growth conditions significantly influence the tillering habit.

In the process of tillering and branching, individuals of tropical grasses form generative (rosette, nonrosette), latent generative, long vegetative (conditionally, temporarily, occasionally sterile, developed, underdeveloped), short vegetative (conditionally, temporarily and occasionally sterile), lateral above ground tillers, stolons (ground-underground, ground, above-ground forms), and stolon like tillers and rhizomes (short metamere, long metamere, "real" and "unreal"). All types of tillers differ in vegetative period, structure, phytocoenotic roles and feed value. Taking into account species and individual variation, perennial Panicoides and Eragrostoides are classified as follows: rhizomic, rhizomic loose tufted, rhizomic stolon formative, loose tufted, loose tuft-stolon formative, and compact tufted.

Tropical grasses are distinguished by three main types of tillering zones (non-specialized rhizome, distinctly detached and stretched), having certain connection with parameters of coleoptile and epicotyl; uniform and interrupted formation of tillering zones; acrotonic, mesotonic and basitonic tillering; marked differences in the tillering habit of different tiller types; and the diversity of the tiller-types and vital forms. The peculiarities of tillering are associated with difficiences in spreading and feeding value.

Key words: Panicoides, Eragrostoides, tillering types.

6-1-5 Seombadi (Dystaenia takesimana (Nakai) Kitagawa), a New Forage Plant: Its Germination and Early Growth Characteristics

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Seombadi(Dystaenia takesimana(Nakai) Kitagawa) is a member of the Apiaceae(Umbelliferae) family and is ecologically adapted to the island of Ulneung, situated 160km off the east coat of the Korean peninsula. The plant is an important forage for livestock on the island, but, because of a lack of knowledge about its germination and slow establishment characteristics, the sowing of the species on the mainland of Korea has been only on a limited scale.

The objectives of our studies were to examine the seed characteristics and factors affecting germination of seombadi, and to evaluate the depletion of seed food reserves and elongation of organs of seedlings during germination and initial seedling periods.

Lipids made up 28.7% of the total dry material in seombadi seeds. The imbibition rate of the seeds with wings intact, wings removed and KOH treated for 5 hours were 29, 40 and 65% respectively. Removal of the wings significantly improved germination. Sections of the seeds showed waxy layers between the wings and seed coat. Germination tests showed an increase in germination percentage with increasing seed weight. Seeds lost their viability rapidly 45 days after harvest and germination reduced to 0% after one year. Light neither inhibited nor improved germination. With high temperature treatment the percentage germination was increased from 44.3 to 91.3%. Soaking the seeds in water for 6 days with the wings removed increased germination.

The higher imbibition and germination of seombadi seeds after wings removal and with the seed coat weakened by mechanical and chemical treatments indicate that the wings and seed coat contain a high percentage of wax which might inhibit germination of the seeds.

Seedling growth in seombadi is slower than in alfalfa and orchardgrass. Of the species examined seombadi recorded the least loss of weight from the seeds during germination.

As a result of these studies, it is suggested that the establishment of seombadi under the mainland environments could be improved by hastening germination with mechanical and chemical seed treatments.

Key words: seombadi, Dystaenia takesimana (Nakai) Kitagawa, forage plant, germination, growth characteristics.

6-2-1 Responses of Alfalfa to a Simulated Midwinter Thaw

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Effects of a freezing-waterlogging-freezing treatment, under controlled environmental conditions, on the percent survival and viability, and on the concentration of carbohydrates, proteins and anaerobic metabolites of alfalfa, Medicago sativa L., were determined to assess physiological responses of alfalfa to midwinter thaw. Alfalfa plants taken from a field were more resistant to freezing, but less resistant to waterlogging, than those grown in a greenhouse. Both types of plants sustained much more severe damage from the second freezing than from the waterlogging. There was a considerable decrease in freezing resistance during the waterlogging. In response to the stress treatment, some metabolic changes occurred in alfalfa roots, such as an accumulation of ethanol and methanol, a solubilization of proteins and a decrease in total available carbohydrates. These findings suggest that resistance to freezing immediately after waterlogging is the most critical factor for surviving a midwinter thaw.

Key words: alfalfa, Medicago sativa, L., winter hardiness, winter thaw, waterlogging, freezing, ethanol, soluble protein.

6-2-2 A Relationship Between Physiological Waterlogging Injury and Root Nonstructural Carbohydrate in Lucerne

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A unifying concept to explain relative tolerance of lucernes to physiological waterlogging injury has proved elusive, due to factors which include stage of regrowth, temperature, severity of waterlogging and the presence of confounding root pathogens. Recently defoliated lucerne is particularly sensitive to waterlogging and a contemporary interpretation implicates the reduced leaf area available for gas exchange. Concomitant with shoot regrowth after defoliation, however, is the sequence of depletion and accretion of labile root carbohydrates. It can be hypothesised that root carbohydrate status may influence the amount of cellular disruptive products formed during anaerobic metabolism. The objective was to explore relationships between waterlogging injury, root carbohydrate status and shoot growth in recently defoliated plants.

Cultivars Siro Peruvian, Hunter River (Medicago sativa L.) and Walkabout (M. falcata L. x M. sativa L.), each with 0, 4, 8, 12 and 16 days of regrowth, were assessed for injury after 15 days of waterlogging in pasteurised soil at 32/24°C. Plants were 90 ± 8 days old grown in free-draining pots before waterlogging, sowing being sequential over 16 days to permit simultaneous waterlogging of the regrowth treatments. Waterlogging was achieved by immersing pots in water maintained 2 cm below the soil surface. Root and shoot characteristics immediately before waterlogging were determined on replicate plantings treated identically to those waterlogged.

Tap-root carbohydrate contents before waterlogging varied between 21-40%, the lowest contents occurring for all cultivars in plants having 12 days regrowth, and shoot (including the crown) dry matter ranged between 0.06 - 0.30 g plant^{-1}. A negative, linear relationship ($r = -0.90$) common to all treatments was found between root injury, expressed as the relative reduction in tap-root weight during waterlogging, and the percentage of total non-structural carbohydrate in the tap-root at the commencement of waterlogging. Root injury was poorly correlated ($r = +0.50$) with shoot weight before waterlogging.

The regrowth stages examined were mostly confined to the carbohydrate depletion phase following defoliation. Further study to determine if the relationships described might also apply in the carbohydrate accretion phase of the regrowth cycle appears warranted. A more comprehensive understanding may prove invaluable for devising irrigation strategies to minimise injury, for determining whether real differences in genotypic tolerance exist and for developing selection methodology in breeding programmes.

Key words: lucerne, M. sativa L., M. falcata L., waterlogging, root carbohydrate.

6-2-3

Comparative Flooding Tolerance of Tropical Pasture Legumes

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Growth and persistence of many tropical pasture legumes can be limited by flooding or waterlogging. Selection of tolerant species is important for pasture development in the humid lowland tropics. The aim of this project was to compare the flooding tolerance of seven tropical pasture legumes and to determine whether the pot technique we developed was reproducible and relevant to the field situation.

Plants were grown in pots and at the start of flowering were flooded to 15 cm above soil level. Water temperature and oxygen content was monitored regularly. Sets of 4 uniform pots were removed after 7, 14 or 21 days, and after 7 days recovery the dry weight of tops, roots and nodules of the flooded and matched sets of non-flooded controls were compared. The ratio of dry weight flooded/dry weight control was an index of tolerance. The species were ranked as follows in index values:- Macroptilium lathyroides (1.04 and 0.87), D. intortum (0.85), Pueraria phaseoloides (0.76), Stylosanthes guianensis (0.62), Macroptilium atropurpureum (0.44), Centrosema pubescens (0.37) and Desmodium uncinatum (0.34).

Root growth was more affected by flooding than shoot growth. Nodulation was drastically reduced in all species except M. lathyroides. The adaptation of M. lathyroides was related to a rapid production of adventitious roots from the submerged stem and rapid renodulation of these and other roots. D. intortum also had rapid adventitious root production but no renodulation. The screening technique appeared to yield reproducible results and the rankings were related to field observations.

Key words: flood tolerance, tropical pasture legumes, Macroptilium, Desmodium, Stylosanthes, Centrosema, Pueraria.

6-2-4 Salt Grass (*Distichlis spicata*) as a Potential Forage Crop Irrigated with Saline Water

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There is an increasing demand for water for urban and industrial uses as well as for irrigated agriculture in the western U.S. Much of the water available to meet this demand is in underground supplies, but a large proportion of this water is saline. Desalinization is costly at present and needs a large input of energy; it is, therefore, important to develop crops that can tolerate high levels of salinity. A species that may have considerable potential as a forage crop is salt grass (*Distichlis spicata*). This species is common throughout the U.S. in brackish ponds and salt flats, and has been observed to grow in soils with salt concentrations from 300 to 56,000 mg/liter Total Dissolved Solids (TDS). Salt grass is consumed by range livestock and from samples taken from rangeland it has been shown to have a forage quality similar to early-bloom timothy hay. Dry matter production in salt marshes has been estimated up to 6.5 tons/ha.

Salt grass fixes CO_2 by the C_4 dicarboxylic acid pathway and studies have been initiated to determine its response to increasing salinity. Plants were grown at 3 salinities (6, 15,000, 30,000 mg/l TDS) and two temperatures (35°C light/25°C dark and 25/15°C). When salt grass was grown at low salinity (6 mg/l TDS), it exhibited very high rates of net photosynthesis (Pn) up to 70 mg $CO_2/dm^2/hr$, and did not become light saturated under full sunlight conditions. At the low salinity, the plants grown under the higher temperatures had higher rates of Pn. When plants were grown at high salinity (30,000 mg/l TDS), rates of Pn were less, but still reached 25 mg $CO_2/dm^2/hr$. The decreased Pn with higher salinity was a function of increased stomatal resistance (r_s) for the plants grown at 35/25°C. Since the stomatal density remained the same, it was assumed that there was a change in stomatal aperture as salinity increased. However, for plants grown at 25/15°C, Pn decreased as a function of both increased r_s and increased mesophyll resistance (r_m). Stomatal density decreased, so the increase in r_s could be partly attributed to this. Leaf thickness and the ratio of the mesophyll area to leaf area did not change with increased salinity, so the increase in r_m was not attributed to these but rather to biochemical changes. The response of salt grass to increased salinity was therefore partly due to both physiological and morphological changes, and there was an interaction between temperature and salinity.

Salt grass was able to maintain high rates of Pn at high salinities and apparently can produce a considerable quantity of forage of reasonable quality. Accordingly, field plots are being established to determine the feasibility of using salt grass as a forage crop irrigated with saline water.

Key words: salt grass, *Distichlis spicata* (L.) Greene, salt tolerance, photosynthesis, stomatal resistance, mesophyll resistance

6-3-1

Response of Siratro (*Macroptilium atropurpureum*) to Water Stress

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The twining perennial legume Siratro (*Macroptilium atropurpureum*) is one of the most successful plants used in pastures in the seasonally-dry tropics and subtropics of north-eastern Australia. Because rainless periods lasting many weeks are common in this region, the plant is necessarily well adapted to withstand periods of water stress. The purpose of these studies was to understand which adaptive characters contribute to its success.

Siratro was grown in the field and in controlled environments and subjected to a sequence of water stresses. Measurements were made of tissue water relations, leaf gas exchange, leaf movement and leaf energy balance.

Part of the success of Siratro is undoubtedly due to its ability to avoid the effects of stress by maintaining leaf water potential greater than -20 bar, while grasses grown in association with it (*Cenchrus ciliaris* and *Panicum maximum* var. *trichoglume*) are about -60 to -80 bar. This high degree of avoidance is essential for survival because we found the tissues of Siratro were not able to tolerate leaf water potential less than about -24 bar. Siratro made only slight changes in its water relations and its stomatal response when exposed to a variety of water stress treatments either in the field or in controlled environments.

Siratro has three main mechanisms by which it prevents leaf water deficits from developing and by which it maintains relatively high leaf water status.

- Good stomatal control over water loss; the stomata close at relatively high water potential, and also close in response to falling atmospheric humidity independent of leaf water potential.
- Paraheliotropic leaf movements by which the leaves of stressed plants are able to remain substantially parallel to the rays of the sun throughout the day. Paraheliotropy operates to minimize the radiation received by the leaves and can result in them being 8-10°C cooler than leaves held horizontal when plants are experiencing water stress. This in turn reduces the vapour pressure gradient between the leaf and the air, and hence reduces water loss.
- Reduction of leaf area, which reduces the amount of transpiring tissue. As the level of water stress increases, the older leaves are shed; new leaves are smaller, thicker, dark green and hairy. If stress continues whole branches die until only the crown remains, most of which is under the soil surface.

We conclude that although these mechanisms allow Siratro to avoid severe leaf water deficits in many circumstances, its inability to withstand leaf water potentials less than -24 bar makes it vulnerable in extended dry periods. Although water loss is minimized, some loss still occurs and the tissues will ultimately reach a critical level and die. We believe that increasing the ability of Siratro to tolerate water deficits would increase its survival and expand its utility.

Key words: Siratro, *Macroptilium atropurpureum*, water stress, photosynthesis, water relations, leaf movement, adaptation.

6-3-2 Effect of Light, Temperature and Water Stress on Net Photosynthesis of Honey Mesquite

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Honey mesquite (*Prosopis glandulosa* Torr. var. *glandulosa*), a woody perennial of the Leguminosae, is adapted to a broad range of environmental conditions. Results of net CO_2 assimilation rates (P_N) for *in situ* mesquite have been reported in several papers. These studies of *in situ* mesquite photosynthesis, however, do not test between individual plants or plant populations in relation to environmental or physical factors because of the need, in the field, to monitor complete diurnal cycles of P_N. This study was initiated, therefore, to investigate the response of P_N to changes in water stress conditions, temperature and light for two Texas populations of honey mesquite grown under controlled environmental conditions. Concomitantly, effects of these variables on light response curves, and subsequently light saturation points, were also investigated.

Two sites were utilized as a seed source to study P_N in populations of mesquite. The seeds were collected before abcission from a range of parental plants at both sites. Seedlings were grown in a controlled environmental chamber and were ready for experimentation within 6 to 8 weeks. A factorial experiment arranged in a split-split plot design with three replications was used to determine environmental tolerances of P_N from both mesquite populations. A portable, open CO_2 exchange system was used for measuring P_N of the seedlings. Data were summarized using standard analysis of variance techniques. Averaged photosynthetic rates were used to fit a variety of hyperbolic light response models in order to estimate and compare the theoretical maximum net CO_2 assimilation rate and the light use efficiency coefficient for each of the factors used in the study.

Maximum P_N observed during the trials were between 0.69 and 0.82 mg $m^{-2}s^{-1}$. Net assimilation rates were significantly lower in the west Texas population and under high water stress conditions. Maximum P_N, at 1.35 mmol $m^{-2}s^{-1}$ photon flux density, were reached at 20 to 30 C and 30 C for east and west Texas populations, respectively. The response of P_N to light was similar to responses reported for other C_3 species and 81 to 99% of the variability of the data was accounted for by using a hyperbolic light response model. Light use efficiency of mesquite was lower for the west Texas population and under high temperature and water stress conditions. High temperature and water stress treatments also caused substantial decreases in the estimated theoretical maximum net assimilation rates for mesquite. Finally, the light saturation point for the light response models varied depending on population and water stress condition.

Key words: honey mesquite, photosynthesis, light, temperature, water stress.

6-3-3 Plant Water Relationships of Crested, Pubescent, Slender, and Western Wheatgrasses

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Objectives were to characterize development of water stress in field and controlled environments; to determine stress effects on transpiration (E), stomatal conductance (C), leaf water potential (LWP), leaf osmotic potential (LOP), and photosynthesis (P); and to relate measured changes to drought tolerance in crested wheatgrass [Agropyron desertorum (Fisch.) Schult.], slender wheatgrass [A. trachycaulum (Link) Malte.], pubescent wheatgrass [A. intermedium var. trichophorum (Link) Haloc], and western wheatgrass (A. smithii Rydb.). Both LWP and LOP decreased for all species as soil water potential decreased, but not in a 1:1 ratio indicative of maximum osmotic adjustment. The LWP at zero turgor potential ranged from -27 and -28 bars for slender and crested, respectively, to -24 bars for western and -23 bars for pubescent wheatgrasses. Results from field plants suggest a greater degree of osmotic adjustment in crested, slender, and western wheatgrasses as compared to pubescent wheatgrass. For growth chamber plants, based on rate of P, E, and C, western was more sensitive to decreasing soil water potential, followed by pubescent and crested wheatgrasses. Data on species response to water stress are important to development of growth and water use relationships required for predictive models and in management and varietal development.

Key Words: transpiration, drought, water potential, osmotic adjustment.

6-3-4 Leaf Growth and Grain Yield of Wheat in North-South and East-West Rows

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Few experiments report the effect of row direction on growth of wheat in windy areas. The objective of this research was to determine the optimal row direction for winter wheat (Triticum aestivum L. em. Thell.) in the Southern Great Plains of the U.S.A., to minimize stress from the wind and to maximize leaf growth and grain yield.

During a three-year period (1976-1979), the winter wheat cultivar 'Osage' was grown in north-south (NS) and east-west (EW) rows. Wind, soil water content, stomatal resistance, leaf water potential, leaf osmotic potential, elemental concentration of straw and grain, height, leaf area, and grain yield were measured.

The prevailing winds came mainly from the south in the spring, summer, and fall and from the north in the winter. Soil water content was greater in EW than NS rows. Stomatal resistance, leaf water potential, leaf osmotic potential, elemental concentration of straw and grain, and height of plants in NS rows were not significantly different from those of plants in EW rows. Leaf area of plants in NS rows ranged from 5 to 20% more than leaf area of plants in EW rows. During the three-year study, plants in EW rows yielded an average of 11% more grain than plants in NS rows.

The results showed that, where prevailing winds come from the north and south, wheat should be oriented in NS rows for maximum leaf area and EW rows for maximum grain yield.

Key words: winter wheat, Triticum aestivum L. em. Thell., leaf area, grain yield, soil water content, stomatal resistance, plant water potential, plant osmotic potential, height, elemental concentration.

6-4-1 Physiology of Growth of a Grazed Sward

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The objective of this work was to investigate the physiology of a grazed sward and so contribute to the understanding and improvement of grassland utilization under grazing.

Assimilation, utilization and fate of carbon were measured in an irrigated sward of perennial ryegrass (Lolium perenne L.) which was given liberal applications of fertilizer and continuously grazed by sheep at three intensities. An enclosure method and infra-red gas analysis were used to measure CO_2 exchange of the sward; individual leaf photosynthesis and assimilate utilization were measured by combining this method with the use of radioactive CO_2. Intake by sheep was measured by faecal collection and a marker.

Expanding and recently expanded leaves had a high rate of net photosynthesis and contributed most to canopy photosynthesis, especially in the 'hard' grazed sward. Leaf sheaths, whose projected area in the 'hard' grazed sward equalled that of the lamina, had low photosynthetic efficiency and contributed very little to canopy photosynthesis. The high photosynthetic efficiency of leaves in the grazed swards did not, however, compensate for the small leaf area index (< 3) and canopy photosynthesis which decreased progressively as grazing intensity increased. Gross photosynthetic production of the sward was reduced by about a third by 'hard' and by half by 'overgrazing' compared with 'lenient' grazing. Respiration losses accounted for almost half the carbon fixed initially in both 'leniently' and 'hard' grazed swards and about 10% of the photosynthetic production was translocated to the roots in both cases.

The proportion of the photosynthetic production that was harvested as intake was twice as great in the 'hard' compared with the 'leniently' grazed sward, but since photosynthetic production was reduced by hard grazing, actual intake per hectare was only a third greater and intake per animal was greatly reduced. Conversely, the amount of carbon entering death and decay was much greater in the leniently grazed sward.

This study highlighted the conflict between the factors which lead to maximum animal production from grazed swards - a high efficiency of harvesting - against those which lead to maximum sward production - a fully light intercepting canopy of young and photosynthetically efficient leaves. In continuously grazed swards, the resolution of this conflict poses formidable problems. Moreover, rotational grazing, in which sward growth and grazing are separated in time, appears to have provided only a partial solution.

Key words: perennial ryegrass, Lolium perenne L., physiology, photosynthesis, carbon balance, grazing, sheep, intake.

6-4-2 Photosynthesis of Grass Swards Under Rotational and Continuous Grazing

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First-year results are presented on the photosynthesis of grass swards under intensive rotational or continuous grazing.

In rotational grazing, crop photosynthesis was high in spring, declining during grazing but recovering rapidly during regrowth, certainly because of the high photosynthetic capacity of individual leaves and of the great area of active leaves left in the sward. In autumn, crop photosynthesis was rather high initially, declined rapidly during grazing and recovered slowly during regrowth, possibly because photosynthetic capacity of the leaves was lower and the decline with age greater and active leaf area in the stubble was smaller.

Under continuous grazing, crop photosynthesis was rather high in spring despite the low leaf area index, certainly because of the high photosynthetic capacity of the many small leaves. In late summer, crop photosynthesis was lower, possibly because the remaining leaves were old and less active.

Net photosynthesis of continuous grazing integrated over time at 2 radiant flux densities was about the same in spring as for rotational grazing. However in autumn, it was somewhat lower than for rotational grazing. This does not necessarily lead to a proportionally lower herbage production as differences in respiration, translocation and longevity may compensate for the differences. Research is being continued in order to compile an explanatory simulation model and to optimize grazing systems.

Key words: photosynthesis, rotational grazing, continuous grazing, Lolium perenne L., production, leaf area index.

6-4-3 **Photosynthesis and Dry Matter Distribution in Altitudinal Ecotypes of White Clover**

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Productivity of white clover (Trifolium repens L.) is limited by different plant characteristics which prevent efficient use of the environmental inputs. In the temperate zone low temperature often limits growth. Comparisons of ecotypes originating from sites with cool or warm climatic conditions (low or high altitudes) can show, when plants are grown in a common environment, the degree of the adaptation of processes related to net photosynthesis and distribution of dry matter. Our objectives were to determine the photosynthetic responses to temperature in relation to the thermal regime during growth stages and effect of temperature and daylength on partitioning of dry matter and nonstructural carbohydrates.

Vegetatively propagated plants from 600 (valley-type) and 2000 m above sea level (alpine type) were grown in the field and in growth chambers. Photosynthetic rate and assimilate distribution were determined. The alpine genotype and plants grown at low temperature showed relatively high photosynthetic rates at 3 C but limited photosynthesis at 24 C, probably due to intracellular shortage of CO_2 and increased photorespiration. The valley genotype and plants grown at higher temperature showed high photosynthetic rate at high temperature, but a relatively low rate at low temperature, probably due to the decreased concentration of photosynthetic apparatus per unit leaf area. At low temperature pool sizes of metabolites of the carbon cycle suggest limitations by other processes than carboxylation. The high rate of photosynthesis of the alpine genotype was not associated with a high forage yield. The lower yield of the alpine genotype cannot be explained by leaf area ratio but by the leaf area index and mean sward height. Growth temperature and particularly daylength, modified the pattern of assimilate distribution more than did genotypes. Plants grown at low temperature showed increased content of nonstructural carbohydrates. This was associated with a greater decrease in rate of leaf appearance than in photosynthesis at decreasing temperatures. In addition, if daylength was reduced at low temperature, 82% of all nonstructural carbohydrates were in the stolons and roots, compared with 55 to 65% in the long days. The higher photosynthetic rate at low temperature and a stronger shift to growth of storage organs of the A-genotype in short photoperiods is consistent with requirements of its ecological origin.

Key words: white clover, Trifolium repens L., photosynthesis, photorespiration, dry matter distribution, nonstructural-carbohydrates, temperature, adaptation.

6-4-4 Differences in Photosynthetic Types in the *Laxa* Group of *Panicum* Genus: Photosynthesis and Photorespiration

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Differences in grasses with the C_3 and C_4 cycles of CO_2 assimilation are well known. The *Laxa* group of *Panicum* is composed of species of tropical origin which have been found to differ in their photosynthetic pathways. The objective of this research was to describe the photosynthetic and photorespiratory characteristics of species in this small group of the *Panicum* genus.

Measurements of CO_2 exchange were made on young, fully expanded leaves in small leaf chambers using infrared gas analysis techniques. Three of the species examined, *P. laxum*, *P. hylaeicum*, and *P. rivulare*, exhibited characteristics typical of C_3 species, that is, about 33% inhibition of photosynthesis by 21% O_2, a CO_2 compensation concentration of about 50 µl l^{-1}, and non-kranz leaf anatomy. *Panicum prionitis* had characteristics typical of C_4 plants, its photosynthesis being insensitive to O_2 and its CO_2 compensation being less than 10 µl l^{-1}. Its leaves also were characterized by features of Kranz anatomy. The remaining three species examined, *P. miliodes*, *P. schenckii* and *P. decipiens* were intermediate between C_3 and C_4 types in above characteristics. Inhibition of apparent photosynthesis by 21% O_2 was about 20% and the CO_2 compensation concentration ranged from about 10 to 25 µl l^{-1}. In addition, photorespiration (CO_2 loss in CO_2-free air) in the intermediate species was only about one third as high as in the C_3 species. The intermediate species possessed a chlorophyllous vascular bundle sheath like C_4 grasses, but the bundle sheath cells were not as nearly filled with organelles as in C_4 species. Photorespiration is reduced in the intermediate *Panicum* species. Apparent photosynthesis rates and the ratio of apparent photosynthesis to transpiration were similar to those of C_3 *Panicums* and about 1/2 as great in C_4 plants.

The reduced photorespiration in the intermediate *Panicum* species appears to be due to a refixation of photorespired CO_2 rather than a reduction in the operation of the photorespiratory pathway. This is indicated by (1) high photorespiration rates as estimated by the post-illumination CO_2 burst, (2) similar effects of O_2 on "carboxylation efficiency" in the intermediate and C_3 species and (3) photorespiration rates equal to those of C_3 species at low light intensity, but which decrease in the intermediate species with increased light intensity.

It is concluded that *P. miliodes*, *P. schenckii* and *P. dicipiens* are intermediate between C_3 and C_4 photosynthetic types. Not enough is known about these species and their relatives to determine whether they are evolutionary intermediates between C_3 and C_4. A better understanding of their physiology, biochemsitry and taxonomic relationship to C_3 and C_4 species should indicate the evolutionary standing of these species and the possibility for reducing photorespiration through breeding.

Key words: C_3 and C_4 species, Kranz anatomy.

6-4-5 Mobilization of Protein from Storage Organs During Shoot Regrowth of Pasture Grasses

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The purpose of this investigation was to compare the nitrogen remobilization from storage organs to vegetative regrowth of orchardgrass (Dactylis glomerata L.) and timothy (Phleum pratense L.) after shoot removal. Roots were removed from stem bases of both species before culturing them in distilled water (low nitrogen treatment) or in sand supplemented with complete nutrient solution (high nitrogen treatment). The heavy isotope, nitrogen-15, was incorporated in the high nitrogen treatment to allow comparison of fertilizer nitrogen uptake with that of reserve nitrogen remobilization.

During the initial 24 h after shoot removal, total protein concentration declined 50% in stem bases of both species. Albumin and globulin decreased in storage organs of orchardgrass, while albumin, prolamine, and residual protein declined in timothy. Timothy removed more nitrogen-15 from solution culture than orchardgrass during the initial 24 h after shoot removal.

Dormant buds of stem bases grown at high nitrogen initiated new shoots within 3 days after the experiment started. In stem bases grown at low nitrogen, shoot initiation from dormant buds required 9 days. Growth of shoots and roots during the 20 day experiment was less from low nitrogen than from high nitrogen plants. Total protein concentration of stem bases declined 52.6% in timothy and 36.8% in orchardgrass during vegetative regrowth. In contrast, globulin concentration increased in orchardgrass and albumin concentration increased in timothy storage organs.

During flowering the organic nitrogen reserves of orchardgrass contained 65.3% protein, mainly as albumin and glutelin. In timothy the organic nitrogen reserves contained 85.4% protein, chiefly as glutelin and prolamine.

The results suggest that the concentration of organic nitrogen reserves in stem bases affects rate of vegetative regrowth and the total yield after regrowth. Part of the protein remobilized during regrowth is used in respiration, and the rest for synthesis of new tissues. The individual protein fractions appear to be equally available to the plant during regrowth. However, the difference in organic nitrogen remobilization at low and at high nitrogen levels in the nutrient solution shows that mineral nitrogen stimulates the remobilization of organic nitrogen reserves. In our experiments, orchardgrass and timothy stem bases supported vegetative regrowth for more than 100 days on distilled water. This illustrates this importance of organic nitrogen reserves in maintenance of pasture grasses during unfavorable growth periods.

Key words: organic nitrogen reserves, nitrogen remobilization, perennial grasses, solution culture, stable isotope, Dactylis glomerata L., Phleum pratense L.

6-5-1 Using Leaf Area Expansion Rate to Improve Yield of Tall Fescue

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Several physiological characters have been proposed for use in breeding programs for higher yield potential. At high tiller density weight per tiller becomes a major yield factor of vegetative canopies. Further, weight per tiller is closely related to rate of leaf area development, a factor with low heritability and high environmental influence. Our objectives were to evaluate recurrent restricted phenotypic selection for developing populations of tall fescue (Festuca arundinacea, Schreb.) for low and high rates of leaf area expansion (LAE). After four cycles of selection from a broad-based population (C_0) we began testing progress by comparing populations and cultivars in field plots.

Four cycles of selection gave populations with rates of leaf area expansion (LAE) of 181 and 74 mm^2 day^{-1} for the high (H) and low (L) directions, respectively. It appeared that LAE changes in early generations were due largely to increased leaf elongation rate (LER) of the H populations, whereas later progress was due largely to decreased leaf width (LW) of the L populations. Overall, LER had a larger effect on LAE than did LW. Number of tillers per plant was inversely related to LAE.

Yield of vegetative regrowth after four generations of selection in the L direction was 25% lower than the C_0 population because the 2.1-fold increase in tiller density was more than offset by the 2.8-fold decrease in weight per tiller. Tiller density was not reduced by selection for high LAE even though weight per tiller was increased. The H_2 population yielded 39% more than the C_0 population because tiller density and weight per tiller were both increased about 20%. Later generations were lower yielding than the H_2 populations, but higher than the C_0 population. Yields of 'Kenhy' and 'Mo-96' were similar, while that of 'Ky-31' was lower than the C_0 population.

Selection for LAE was effective in increasing yield of vegetative growth. The H_2 population was superior, perhaps due to a complementary mixture of large and small plants. Alternatively, inbreeding depression may have limited further genetic advancement. Compared with present cultivars, it appears possible to improve summer and fall productivity by selection for leaf growth rates and optimizing tiller weight. Photosyntheses of single leaves was altered less than 10% over populations after four generations of selection.

Key words: tall fescue, Festuca arundinacea, Schreb., yield components, leaf area expansion rate, leaf elongation rate, leaf width, tiller density, weight per tiller, recurrent restricted phenotypic selection.

6-5-2 Nitrogen Availability and Ryegrass Regrowth

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In grass based pastures, mineral nitrogen availability often acts as a final determinant of dry matter production from the system. To predict responses to fertiliser nitrogen application, a quantitative understanding is required of the functional responses of grass plants to the higher nitrogen availabilities. This paper summarises the results of a number of experiments investigating the physiology of nitrogen responses during the regrowth of ryegrass (Lolium spp.).

Higher levels of nitrogen availability increase the initial rate of leaf area display in single ryegrass plants grown in sand culture. Although photosynthesis rates are concurrently increased, soluble carbohydrate levels in both tops and roots fall more rapidly in high nitrogen plants. It was estimated that this was related to increased respiration rates associated with uptake and metabolism of nitrogen and incorporation of new structural material.

Leaf area production and tillering responses to nitrogen result in new functional equilibria being established within plants. Higher root/shoot ratios reflect greater activity per unit root weight at higher nitrogen availabilities. Increased individual leaf size gives higher leaf/stem ratios.

Where nitrogen availability is increased following floral initiation, in both single plants and simulated swards, reproductive tillers also respond with an initial increase in leaf area display. More rapid stem development at higher nitrogen levels results in increased growth rates and lower leaf/stem ratios later in regrowth. Individual tiller growth rates were lower, and leaf/stem ratios higher in plants grown in simulated swards at both nitrogen levels.

Detailed measurements of field plot ryegrass monocultures in the spring and autumn showed leaf appearance, tillering and tiller growth rates to be increased by high nitrogen nutrition. However, high nitrogen decreased tiller survival following grazing which resulted in lower mean tiller densities. The results indicate that nitrogen affects the capacity of monoculture swards to produce new tillers both by increasing new tiller sites through promoting leaf production and by exploiting existing sites through promoting tiller production.

In ryegrass-white clover based pastures, autumn fertiliser nitrogen application increased tillering rates and leaf production in vegetative swards. Mid-spring application increased growth rates of both reproductive and vegetative tillers, but resulted in increased tiller numbers by reducing vegetative tiller mortality in a period of high tiller death rates.

Key words: nitrogen, Lolium spp., tillering, regrowth, leaf area.

6-5-3 A Descriptive Scheme for the Stages of Development in Perennial Forage Grasses

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A descriptive scheme of morphological stages of development in forage grasses is urgently needed for scientific investigations as well as for practical purposes. It could be used for the precise timing of management measures such as the application of fertilizers and herbicides, and of harvesting with respect to a certain level of forage yield and/or quality. The existing schemes like the Feekes scale and its modifications are devised for cereals. They do not adequately consider the peculiar stages of development of perennial grasses grown for the production of forage.

We propose a scheme which consists of consecutive stages of the following phases of plant development: number of leaves, elongation of leaf sheaths, stem elongation, inflorescence emergence, anthesis, and seed ripening. In an attempt to standardize the schemes, we have adopted the two-digit code and wherever appropriate have maintained the stages and terms of the scale of Zadoks, Chang and Konzak (1974). The complete descriptive scheme is given in the paper.

The association between a certain stage of growth and characteristics of nutritive value depends on the earliness of species and cultivars. At a fixed stage of plant development, the nutritive value in terms of *in vitro* digestibility, crude fibre content and crude protein content is generally lower in late types than in early ones. Inversely, a certain level of nutritive value is reached in late types at an earlier stage of growth than in early ones.

Key words: descriptive scheme, development, forage, grass, growth stage, quality, yield.

6-5-4 Effects of Maturity and Environment on the Amount and Composition of Hemicellulose in Tall Fescue

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Seasonal changes in the amount, composition, and digestibility of fiber in the vegetative tissues of forage grasses are usually associated with advancing tissue maturity. The possible role of environment has not been studied in detail, because the effects of maturity and environment are confounded in most field situations. Our objective was to determine the relative effects of maturity and environment on the amount and composition of hemicellulose in field-grown tall fescue (Festuca arundinaceae Schreb.).

A cutting scheme was implemented which produced replicated plots of tall fescue regrowth of identical chronological age at different times during the growing season. Leaf samples were taken at weekly intervals and extracted with neutral detergent solution to isolate cell walls (NDF). The NDF was treated with 1.0 N H_2SO_4 to remove and hydrolize hemicellulose, and the hydrolyzates were analyzed for concentrations of xylose and arabinose, using high performance liquid chromatography.

Regrowths of the same chronological age (time from previous harvest), but which developed at different times during the season showed different amounts of hemicellulose. Hemicellulose concentration decreased during regrowth occurring in early summer, remained about the same during mid-summer, and increased in late summer. Conversely, xylose concentration in hemicellulose increased during early summer and decreased during late summer, while arabinose concentration remained about the same throughout the season. These results indicate that the effect of time of season was greater than that of tissue age, and imply that environment influenced the composition of the cell wall.

Using growth data, estimates were made of the actual weekly changes in hemicellulose composition of new growth. Calculations showed that the magnitude of differences due to time of season was greater than indicated by the whole-plant data, and suggest that the composition of newly-synthesized cell wall changed considerably during the growing season, conforming more closely to trends in photoperiod than in temperature.

Key words: tall fescue, Festuca arundinaceae Schreb., hemicellulose, maturity, environment, xylose, temperature, photoperiod

6-5-5 Growth and Development of Blue Grass Rangeland in Southcentral New Mexico

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Studies have been conducted on a shortgrass plain in Southcentral New Mexico for the past 15 years to determine patterns of growth and development of blue grama (Bouteloua gracilis). Studies were conducted at the Fort Stanton Experimental Ranch, which ecologically represents all major range sites in Eastern New Mexico. The mean annual precipitation is 38 cm which occurs primarily as summer rainfall. The mean peak standing crop for lowland areas is 1115 kg/ha for hillsides, 830 kg/ha and upland situations 915 kg/ha. Peak biomass may comprise up to 80% blue grama. Data for growth and development studies were collected from replicated plot studies or from specific individual plants within plot studies. Maximum blue grama plant height occurred in mid-July on all areas and was more responsive to environmental changes than leaf height data. Biweekly biomass of plant parts showed a cyclic pattern early in the growing season, corresponding with moisture availability, while cyclic patterns in the dormant season reflect rate of deterioration of standing crop. Seasonal trends in total standing crop parallel leaf blade weight. Nitrogen-enhanced plants had an extended growth period in response to fall moisture, and cyclic patterns were less pronounced. As the blue grama rangelands are subjected to grazing, defoliation effects on growth and development are of primary importance. Plants defoliated throughout the year produced the same standing crop from the same number of phytomers as the control. Rest from defoliation in July and August produced the highest amount of phytomers (40 per shoot) and the greatest standing crop of any treatment. Rest from defoliation in the spring and fall resulted in similar growth and development as observed in control and nonrested plants. Winter rest appears to be as important to growth the following year as rest in July and August. Different strains of blue grama exhibit the same developmental patterns (32 phytomers per shoot) under protection and respond similarly to defoliation. Less productive cultivars have less total leaf length (122 cm per tiller) than more productive cultivars (156 cm per tiller). Different management treatments and range sites may affect the rate and amount of blue grama growth. Management of blue grama can be enhanced by understanding morphological development. Collection of basic information on growth and development are essential for proper decision making and interpretation of grazing results.

Key words: blue grama, Bouteloua gracilis, growth, development, biomass.

6-6-1 Effect of Active Roots of Forage Grass on Soil Aggregate Formation

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Both half-rotted older roots and active younger ones are present in abundance in forage grass and both types assist in soil aggregate formation in their own rhizosphere.

Two kinds of experiments were carried out to elucidate the role of active roots in aggregate formation. Italian ryegrass (Lolium multiflorum Lam.) was grown for 12 weeks in glass boxes placed in a phytotron. A bed of quartz and sand particles 1 mm in diameter was placed in a glass box.

In Experiment I, 3 boxes were used and these were opened after 4, 8 and 12 weeks, respectively. Growth was then checked, and the quantity of sand adhering to the roots weighed. One hundred times more sand was found to be adhering to the roots after 12 weeks than after 4. When this was converted into the quantity adhering to each individual root it was found that the figures at 8 weeks and 12 weeks were both around 2 g, or 10 times greater than at 4 weeks.

In Experiment II, the distribution of pectic substance on root surfaces and points in contact with the surrounding sand was ascertained by the application of ruthenium-red solution. The adjesive strength of this pectic substance was measured using glass plates, and was found to be 15-20 g per single adventitious root. It was also discovered that the total adhesive strength of the roots of each plant increased in proportion to root number.

From the experiments the following conclusions were drawn concerning the function of active forage grass roots. By excreting a pectic substance these active roots cause the adhesion of soil particles in the surrounding area, acting as a first step in anchoring the plant. As the active root system expands the quantity of pectic substance excreted increases rapidly, and the adhesive action affects a wider area, thus leading to aggregate formation.

Key words: Italian ryegrass, Lolium multiflorum Lam., root, soil, aggregates, adhesive action, active roots.

6-6-2 Phenology and Culm Weight Variation Between Two Wheatgrass Species: *Agropyron smithii* and *A. spicatum*

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Knowledge of plant phenology and live weight dynamics are necessary to intensively manage semiarid rangelands. Thirteen sites in Wyoming were sampled for plant phenologic development and culm weights of western wheatgrass (*Agropyron smithii*) and bluebunch wheatgrass (*A. spicatum*). These species are sympatric and allopatric within these rangelands. Environmental data were also collected for use in differentiating sites.

Data on all the variables were collected at fourteen day intervals throughout the growing seasons of 1979-80. Permanently marked plants were sampled for phenology and plants of similar development were collected for culm weight estimates. Cumulative precipitation, degree days, soil water potentials at three depths (0-15, 16-30, and 46-60 cm), soil temperature at 25 cm, and Julian dates were recorded.

A two-way analysis of variance performed on culm weight and phenology data identified 7 groups of similar sites. For the culm weights, western wheatgrass formed 4 distinct groups, bluebunch wheatgrass formed 2 distinct groups, and both species together formed 1 group. The phenologic data revealed the same groupings of sites.

Discriminant analysis of physical site characteristics showed bluebunch wheatgrass to occur on sites with low sand content, high soil pH, low soil moisture, and/or deep rooting depths. Western wheatgrass favored sites with moderate to high sand content, neutral pH, moderate soil moisture and/or shallow rooting depths.

Analysis of micrometeorological variables showed western wheatgrass produced the greatest culm weights at moderate amounts of degree day accumulation and cumulative precipitation. Bluebunch wheatgrass culm weights were greatest at higher values of both variables. Phenologic development was species related, with bluebunch wheatgrass developing more rapidly. Phenology on sites with low culm weights developed more rapidly than sites with large culm weights.

Key words: western wheatgrass, bluegunch wheatgrass, phenology, culm weight.

6-6-3 Morphological Features of the Polish Ecotypes of *Festuca arundinacea* Schreb. and Their Chemical Composition

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The researches[x] were carried out in the years 1975-1980 and included 400 ecotypes of tall fescue /*Festuca arundinacea* Schreb./. Some chosen morphological and chemical features were taken into consideration.

The investigated Polish ecotypes are hexaploidal forms with a constant number of chromosomes 2n=42. There are great morphological differences among them. These differences are visible also in the biology of ecotypes, in the yield and in chemical composition of the plants.

In the Polish ecotypes gathered in the Poznań collection the vegetative stems are approximately 60 cm long, the area of leaf blade on the vegetative stem - 25.81 cm^2. The angle between the leaf and the stem is 18.39^o on average.
The mean contents of chemical compounds are: total protein - 21.29%, crude protein - 14.22%, soluble carbohydrates - 7.00%, fibre - 24.56% and silicon -0.54% in dry matter. The mean content of the alkaloid perloline is 355.11 μg/ g d.m., but in 69% of the ecotypes perloline was not found.

Among the analysed features the most important proved to be the length of the vegetative stems, the middle leaf inclination angle, the areas of leaf blades and the leaf borders. These features can supply an approximate indication of the chemical composition of tall fescue. Ecotypes with less obtuse inclination angle of the middle leaf position on the stem 20.50^o and with a mean length of stem 52.53 cm characterize by the most favourable chemical composition. These ecotypes should be used in further works breeding on this species.

Key words: tall fescue morphology, chemical composition, digestibility.

[x] The researches were financed by the Department of Agriculture U.S.A.

6-6-4 Relationships Between Root and Shoot Growth of Alfalfa Under Various Treatments

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Alfalfa (Medicago sativa L.) is a perennial plant with a characteristic root system consisting of a thick taproot and numerous lateral roots. The contribution of each root system (taproot or lateral roots) to herbage production of alfalfa is not yet known. The author separated lateral roots from taproot, and compared the growth relationship between individual root and shoot with special reference to dry-matter partition.

Shoot-root weight relationships under different treatments were compared on alfalfa (var. Du Puits) seedlings growing in pot-cultures. Treatments were fertilizer (no and complete), soil temperature (10, 15, 20, and 25°C), soil structure (clay to sandy soil), day-length (8- and 16 h), and cutting frequency (3- and 5-week interval).

(1) With all treatments, high positive correlations were observed between shoot and total root weight; shoot weight increased as total root weight increased. (2) Shoot weight was proportional to lateral root weight under all treatments, suggesting that increased root surface by growth of lateral roots favors uptake of nutrients from soil media. (3) Taproot growth increased under conditions favorable for shoot growth, but as taproot increased in weight, correlations between taproot weight and shoot weight decreased. This suggests that taproot growth depends on the supply of assimilates from shoots which are to be accumulated as food reserves and decreased as utilized for further shoot growth. (4) Thick taproot increased lateral root formation, but decreased the weight of individual lateral roots. It is assumed that increased formation of lateral roots with thick taproot was due to increased root surface allowing lateral root initiation, but decreased weight of lateral roots resulted from a decreased food supply from the taproot.

It was concluded that root contribution of alfalfa in relation to shoot growth seems to change with growth stage; in the early stage of growth, shoot growth increases with root growth functional for nutrient uptake, but upon further shoot growth, assimilates produced by shoots are translocated to result in taproot thickening. Thickening of the taproot decreases nutrient uptake ability but increases accumulation of food reserves, allowing formation and growth of lateral roots which produce higher shoot growth. As roots grow further, the taproot continues to thicken enough for excessive food reserves to decrease lateral root growth and bring lower lower top/root weight ratio.

Key words: alfalfa, Medicago sativa L., root growth, shoot-root relationships.

6-6-5

Dry Matter Production and Non-Structural Carbohydrate Accumulation in *Lotus corniculatus* as Affected by Cutting Treatments and Maleic Hydrazide

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Lotus corniculatus, L. (Birdsfoot trefoil) is a relatively long-lived perennial forage legume particularly in the higher altitudes of the cooler termperate regions. Within these regions, the plant persists among a wide variety of soil conditions. Plant persistence becomes rather variable when grown in the warmer regions of the temperate zone, especially when subjected to environmental stress during periods of high temperatures. A major factor contributing to the low degree of tolerance to environmental stress conditions is likely associated with the relatively low level of total non-structural carbohydrate (TNC) accumulation during the active growth period. The objectives of our studies were to determine the effects and potential interaction of cutting or defoliation treatments and the growth regulator, maleic hydrazide (MH) on the accumulation of TNC and dry matter production.

Our studies consisted of two separate field experiments. Experiment I was conducted on a mixed sward of *Lotus corniculatus*/*Festuca arundinacea* subjected to three different aftermath cutting treatments: uncut, cutting immediately prior to the MH application, and cutting six weeks after the MH application. Three rates of MH, 0, 1.68 and 3.32 kg ai/ha, were applied to each of the three cutting treatments. The MH application resulted in delayed flowering and altered bud development with no apparent effect on TNC accumulation or dry matter production.

Experiment II consisted of three fall cutting schedules: dormant cutting, recommended cutting schedule and a late cutting schedule, with each cutting regime treated at two rates of MH (0 and 1.68 kg ai/ha.) applied two weeks after the last regular cutting. Yield data obtained the following spring showed that the MH treatment had no effect on dry matter production. However, MH reduced the TNC depletion by 10 to 12%. Plots which were not harvested during the late season, i.e. the dormant cutting, showed increased TNC levels and greater root dry weights compared to the other two cutting regimes.

Our data showed that the late summer application of MH increased the relative level of TNC during the overwintering period. However, the mid-summer application of MH did not significantly increase TNC levels during the potential mid-summer environmental stress period.

Key words: *Lotus corniculatus* L., birdsfoot trefoil, dry matter production, carbohydrate accumulation, maleic hydrazide.

7-1-1 The Ecology of Yang-cao (Leymus chinensis) Grasslands in Northeast China

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The Yang-cao (Leymus chinensis) grassland is the typical one of the east region of Europe-Asian Steppe zone. Its area is up to about 4,000,000 km^2. To clarify the ecological characteristics of the grassland is the aim of this paper. The study method is conformed to IBP. Through ten-year observation, it has been found out that net primary productivity per year is x=270g dw/m^2 average (standard deviation S=61.72g); and that the limiting factors lie in the quantity of rainfall during the elongation stage in the macrolevel and thickness of the soil of layer A in the microlevel; and that the mathematical model of yield: y=76.82 + 5.08x (x=variable of precipitation during May, June, and July).

The height of plants in the community is about 50 cm. The maximum standing crop appears in early August. The time of maximum biomass underground is one month later than that above ground. The ratio of underground biomass to overground biomass (U/A ratio)= 1:8; the ratio of overground organs, assimilative to unassimilative= 1:2 (in average of year); the minimum value appears at the end of June, i.e. the florescence of Yang-cao (Leymus chinensis).

The composition of life-form spectrum of the community was as follows: M1.6%, Ch5%, M58.3%, G25.7%, Ph6.4%. The number of buried-soil seeds 0-5cm below the ground was 1900/m^2, and 54/m^2 in the depth of 5-10cm, in which the ratio of monocotyl is 1:2.1. The number of species was 8-15/m^2. The number of stems was 440-710/m^2. In middle of August, LAI=0.8-1.4m^2/m^2 on the chestnut soil and up to 2.0m^2 on the chernozem. The average transpiration efficiency of community was 0.7g/g/hr. It was in a meso-xerophilous grassland.

The content of N and P in mown grass in summer was greater than that of grass standing dead in winter, 69% and 41%, respectively. Yang-cao is suitable to be used for haylands. By the quantitative nalysis of underground water-soil-plants and of hairs of horses, cattle and sheep, a concentration process of Ti was found. The research on the material cycle of the ecosystem will be going on further. The conclusion of this paper may be compared with the other papers on grassland in the temperate zone, and may throw light upon management in grasslands.

Key words: Yang-cao, Leymus chinensis, grassland, primary production, mathematical model, life-form spectrum, material cycle.

7-1-2 Tropical Pasture Management in Kenya

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For many decades Kenya has been a leading country in terms of research-backed, though farmers-initiated, development of tropical grassland. No other tropical country sees such a high percentage of the arable land under artifical pastures. This is reflected in a thriving commercial grass seed industry, with some 2000 ha of certified seed of varieties of indigenous origin.

Low-intensity grassland development is practised in the range areas, applicable to about 70% of the country which is arid or semi-arid. Drinking water supply and controlled grazing are the obvious primary principles of management, but haymaking and irrigated fodder crops are commonly found on the better farms.

High-intensity development with artificially established pastures is conducted in the more humid zones along two principal lines:

1. On small mixed farms in the main milk-supplying markets dairy animals are increasingly fed indoors with cut grass, mostly planted elephant grass (Pennisetum purpureum), or green maize. It is not sufficiently realized that this system has its roots in factors such as land fragmentation, lack of fencing on otherwise intensively cropped land, and such traditional reasons as cattle theft, protection against tsetse and ticks, and cutting of elephant grass for mulching in coffee. These are obvious reasons. Attempts, however, to ratify this system as efficient from the points of view of land, labour, and milkyield have failed. The strongest argument militating against the system is the drain of fertility from forage fields which do not see fertilizer nor the return of manure.
2. Since the 1930s a spontaneous system developed on farms to rotate the monoculture of wheat or maize with sown grasses of tropical species: Rhodes grass (Chloris gayana) and setaria (Setaria sphacelata). In fact, this enabled the survival of efficient cereal farming, which had otherwise become impossible due to the violence of noxious grass weeds and the depletion of soil organic matter and nutrients. Mixed farming is still the cornerstone of Kenya agriculture, both small and large scale. In spite of 50 years of searching, no legume has been found to associate and persist well in combination with sown tropical grasses. In this, Kenya differs not from Australia or tropical America. Success is limited to rare combinations of species and ecological niches, from which one cannot generalize. Good grazing management, including haymaking and strategic application of nitrogen aimed at maximization of young grass, gives much more flexible systems. Research centers should shift their attention more to these aspects, which have been neglected since all attention was concentrated on tropical legumes.

Key words: tropical pasture management.

7-1-3 Biotic Climaxes on Short Growing Season Lands with Wet Winters and Springs, Dry Summers

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The snow drifts off the Idaho fescue (Festuca idahoensis)bluebunch wheatgrass (Agropyron spicatum) sites. The snow ends up in the swales that grow deciduous brush. The cows will pick on the chokecherry (Prunus virginiana), service berry (Amelanchier), ninebark (Physocarpus malvacius) when the range feed is short or dry. Cows don't eat rosebush (Rosa articularis), snow berry (Symphocarpos crephilus), thornapple (Rhamnus). With the snow moisture that drifts from the grass sites the brush sites could grow so much good feed, but grow so little.

It has been possible to turn the brush sites to biotic climaxes of grass and legume. One brush site on the ranch has been growing alfalfa (Medicago sativa C V Nomad), intermediate wheatgrass (Agropyron intermedium)and Kentucky bluegrass (Poa pratensis) for 34 years.

Factors that determine a biotic climax are considered:

The fertility that the grazing depletes, uses up, needs to be replaced. If a high level of soil fertility isn't maintained plants with a low fertility requirement take over.

Alfalfa fixes large amounts of nitrogen. It grows its tap roots into large supplies of potash and phosphate. Alfalfa thrives on the deep, well drained brush site soils.

The animal manure and urine along with the fertility contained in the ungrazed legume growth provides most of the fertility needed. The red coloring of the grass leaves indicates the need of phosphate fertilizer. Lime is spread to maintain a high ph and to supply the legume with needed calcium. The animal excretia falls on the grass growing areas since the cows are not allowed to move away for shade or water.

Most varieties of alfalfa are killed by root feeding of the pocket gopher (Thomomys spp.). However, the nomad variety of alfalfa, with the ability of adventitious regrowth from cut-off roots, is not killed by such feeding. Nomad alfalfa also grows branch tap roots that enable it to live long.

Grasses that form sods, as intermediate wheatgrass and Kentucky bluegrass, withstand root feeding by the pocket gopher. Orchardgrass (Dactylis glomerata), although adapted to utilizing the moisture of wet springs, withstanding the dry summers, is killed by the root feeding.

The grasses and legumes are allowed to grow tall and are then grazed off in a relatively short time. Allowing for tall growth in the long May-June high-humidity photoperiod enables the plants to use the moisture and occupy the space. With the plants growing tall, moisture from the lower soil horizons is exhausted, effecting the gas exchange.

To effect a complete change the original brush needs to be completely killed before seeding. The thick cover of a legume-fertilized grass keeps out seedlings. Brush that regrows from roots will increase.

Plowing 50cm deep or bulldozing soil from the adjacent benches to cover the brush has been found effective in killing it. Covering with benchland soil eliminates the problem of excess nitrate. Where the brush is cultivated out, the release of nitrate gives the seeded grasses undue competition over the legume seedlings.

The biotic climax of grass and legume on brush sites produces low-cost forage. The prorated cost of establishment is low.

Key words: deciduous brush, nomad alfalfa (Medicago sativa cv Nomad), pocket gopher, biotic climax.

7-1-4 Cool Season Annual Clover Performance on the Gulf Coast

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Cool season annual clovers play a major role in U.S. Gulf Coast pasture systems because they extend the grazing season, utilize atmospheric nitrogen, and produce high quality forage. Three to four cultivars of arrowleaf (Trifolium vesiculosum Savi.), crimson (Trifolium incarnatum L.), and subterranean (Trifolium subterraneum L.) clovers were compared for germination, seedling growth, estimated N_2-fixation, and dry matter production under Gulf Coast conditions. Experimental design was a randomized block with four replications for all studies. Plots consisted of six 25-cm rows, 4.5 m long.

Germination tests were conducted with 12-hr light and dark periods under day/night temperature treatments of 35/25, 30/20, 25/15, 20/10, and 15/5 C. Crimson clover exhibited good germination across all temperature treatments and had the fastest germination rate, followed by subterranean and arrowleaf. Subterranean clover germination was depressed only at 35/25 C, with the best germination rate at 30/20 C. Temperature treatments of 30/20 and 35/25 C severely depressed arrowleaf germination to only 17 and 9%, respectively.

Seedling weight, leaf number, and nodule number were compared by sampling seedlings 4 and 7 weeks after planting. Significant differences in seedling weight between species decreased from 4 to 7 weeks, but subterranean clover was always the heaviest, crimson intermediate, and arrowleaf the lightest. Differences in leaf number at 4 weeks were small but significant, with species ranking subterranean> crimson>arrowleaf. By 7 weeks, subterranean seedlings had twice as many leaves as arrowleaf, with crimson intermediate. Nodule number ranking was subterranean>crimson>arrowleaf.

Symbiotic N_2-fixation was estimated by difference in nitrogen (N) content of the harvested forage from ryegrass (Lolium multiflorum Lam.) receiving no N fertilizer and clover. Estimated nitrogen fixation averaged over 2 years on two soil types for crimson, arrowleaf, and subterranean clover were 57, 73, and 105 kg N/ha, respectively. Crimson and arrowleaf N_2-fixation was reduced 50 to 61% on clay soil.

Dry matter production on fine sandy loam soils was quite variable from year to year, depending on rainfall distribution during the growing season. Usually arrowleaf production exceeded or equaled subterranean clover, with crimson always lowest because of it's earlier maturity. On poorly drained clay soils, subterranean clover produced 60% more forage than arrowleaf and crimson clovers.

Faster seedling growth and earlier germination of subterranean and crimson clovers indicate they would be the easiest to establish and most competitive in grass mixtures. Arrowleaf clovers are the most difficult because of the limited temperature range for optimum germination and the poorest seedling growth. All species were productive on sandy loam soil but subterranean clovers were superior on clay soil.

Key words: arrow leaf clover, Trifolium vesiculosum Savi., crimson clover, Trifolium incarnatum L., subterranean clover, Trifolium subterranean L., seedling vigor.

7-1-5 Increase of Natural Grass Stand Production in the North-Yenisei Flood Plain

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The most effective way of increasing natural grassland productivity is fertilization and rational use of haylands. In 1973-1978 we studied the influence of fertilization, harvesting time and number of cuttings on yield and botanical composition of natural grass stands of forb-grass meadows in the central flood plain of the Yenisei river.

The areas of the experimental plots were: for level of fertilizers, 400 m^2; control area, 50 m^2; and cutting time, 100 m^2. The plots were replicated 4 times. Ammonium nitrate, double granulated superphosphate and potassium chloride were applied in spring after the flood time. The cutting of grass stands was carried out at the stages of heading, flowering, and beginning and full bearing of the meadow foxtail. The second cutting was performed at aftermath height of 25-30 cm.

The soil in the experimental plots is alluvial, sod-meadow, mid-loamy, containing 5-6% of humus, 14.7 mg readily hydrolyzable nitrogen, 12.2 mg of mobile phosphorus, and 9.5 mg of exchangeable potassium per 100 g soil.

Nitrogen fertilizers N_{60-120} with $P_{60}K_{90}$ raised yield of grass stands by 1.5-2.5 times, increased the levels of crude protein, raw ash, and amino acids, and improved the microelement composition of forage. Phosphorus-potassium fertilizers alone had no significant influence on yield of meadow grasses; therefore their use without nitrogen fertilizers is not advisable.

Early harvesting of the meadow grasses allowed two cuttings but total yield of dry matter was less than for a single cutting at later periods. Cutting at later periods markedly increased the proportion of tall forbs in the grass stand. Increased cuttings increased the short grasses in subsequent years at the expense of tall grasses. With the change of the regime from early to late harvesting the quality of the forage declined. Protein quantity decreased by 4.2-5.6%, carotene decreased 1.4 times and cellulose content increased by 1.1-1.5%.

In our experiment (1978) we achieved results close to the predicted yield of 17-25 quintals of dry matter per ha. Fertilization of meadows increased the coefficient of use of photosynthetic active radiation by meadow grasses from 0.66% in the control to 1.33% with the $N_{180}P_{115}K_{130}$ level.

Our results have shown that meadow fertilization permits programming crop productivity and species composition of grass stands and allows two cuttings in the meadows of Zapolyarya. Twofold cutting without fertilization sharply reduced meadow productivity. Continuous cutting of meadow grasses alters the botanical composition of the grass stands. Alternating between early and late periods of cutting contributes to preservation of the valuable species of grasses and high productivity.

Key words: fertilization, cutting rate, yield, botanical composition, grasses.

7-2-1 Basic Types of Pasture Vegetation in the Songnen Plain

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In this paper, the ecologic conditions of pasture vegetation, the constituents of plant population on the Songnen plain, and their basic types and the succession are discussed. At the same time, an approach to some ways of artificial improvement on natural steppe have been suggested. In addition, two maps of pasture vegetation (1/200,000 and 1/750,000) with 170,000 km^2 are presented. In this region, there are 29 lignosa associations which are suitable for grazing and 450 plant species which are suitable for forage. Among them, more than 30 species belong to fine grass of perennial gramineous and leguminous plants.

Key words: Songnen Plain, improvement of natural steppe, pasture vegetation, lignosa associations, gramineous plants, leguminous plants.

7-2-2 Grassland Agriculture in the Tropics and Subtropics of China

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Making full and reasonable use of all the agricultural resources is one of the signs of the modernization of agriculture. Therefore it is of great significance in developing agricultural production to make a thorough investigation on agricultural resources and form a correct evaluation of them.

Our study indicates that the appearance of the woodless phenomena in the tropics and subtropics of China, the basic factor of the formation of grassland, is mainly the result of man's economic activities there. According to the statistics, the grassland covers about 67,000,000 ha., where the climate is warm and rainfall abundant. There are rich resources in feed and varieties of forage plants. Also domestic animals and poultry are various in breeds and strains. The conditions for developing animal husbandry there are fine and favorable.

There are 189 genera and 1,150 species of graminaceous plants, and 139 genera and 1,130 species of leguminous plants in our country. About 80 percent of them are widely distributed over the tropics and subtropics. They are of great value in cultivating varieties of crops and forage plants.

It has been found through investigation that the conditions of ecological environment and the economic type of the mountain area have a tremendous effect upon the composition of animal-herd and the body-measurement appearance and productivity of domestic animals. The "scaling-style" economic system of mountain areas has inbred domestic animals of all kinds in a narrow region for hundreds of years. The excellent and pure inbred-unfailing livestock breeds built through long artificial selection have greatly enriched the heredity gene-pool of livestock of our country.

The grassland-agriculture in the tropicsand subtropics of China is of a unique character and quite strong in self-support. The so-called "organic-agriculture system" built up through long agricultural practice has now become the basis of the advanced "Chinese-type" agriculture. From the viewpoint of the balance of matter and energy in ecology, every crop rotation system will be examined by the basic law of ecological system.

The questions on the grassland agriculture in the tropics and subtropics of China are: not highly specialized agriculture and the maladjustment in agriculture, forestry and animal husbandry. Our country will make good use of the resources of grassland to develop grassfed livestock-cattle, sheep, horse, rabbit, etc. Thus the relations within the structure of agriculture will be more reasonable.

Key words: grassland-agriculture, resources(forage plants, domestic animals), "organic-agriculture system".

7-2-3

Climo-Edapho-Vegetational Relationships in the Grazinglands of Western India

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Western India is an arid to semi-arid region, an almost flat, sandy country constituting the Great Indian Desert. Grazinglands are the cultivable and noncultivable wastelands around villages and urban areas. Cattle are allowed to graze freely in these areas in daytime and return to their abodes by evening. The vegetation on the grazinglands comes up only during the monsoon months of late June to October, which can be termed the growth period. The net primary production of these grazinglands is governed by a complex of mode and magnitude of driving (of animals to pasture) and abiotic state variables.

To understand the interrelations between the driving, abiotic and biotic variables, studies were carried out in a grazingland ecosystem near Rajkot, situated in Western India. Fortnightly field observations, for a year, were made of precipitation, air temperature, relative humidity and soil factors, namely, moisture, temperature, field capacity, water-holding capacity, total nitrogen, organic carbon, available sodium, potassium and calcium. Estimates of above-ground and below-ground phytomass were made on the same dates.

Simple correlation coefficients were computed between driving variables, abiotic state variables and primary producers. It is found that the driving variables are correlated significantly with the soil temperature, soil moisture and soil organic carbon only, whereas the soil-available minerals and nitrogen have no significant correlations with the driving variables. Direct significant correlations were obtained between the mode and magnitude of above-ground, below-ground and total phytomass with the precipitation, relative humidity, soil moisture and soil organic carbon. Correlations with all other factors were found to be non-significant.

Multiple regression analysis was carried out for the fortnightly observations of total phytomass as a function of combined effect of driving and abiotic state variables. Value of 'r' has been worked out to be 0.82, which is a significant correlation. The variations in the mode and magnitude of the phytomass are governed by a complex of driving and abiotic state variables. Though, individually, certain factors are correlative and others are non-correlative to the variations in the phytomass structure, a combined effect of all the factors is found to be highly significant. Therefore, the variations in the primary producers, in grazinglands, is a function of a complex of climo-edapho factors and is not a function of any single factor.

Key words: grazinglands, arid, semi-arid, abiotic, biotic, driving variables, primary producers.

7-2-4 The Grasslands of Turkey and Their Management

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In Turkey, grassland ranks first in agricultural area, covering 21.5 million ha. Although of great importance for stock rearing and for erosion control, its acreage is decreasing in favor of arable land. This is happening in spite of the continuous increase in stock numbers. Of the total grassland 20 million ha is in natural pastures distributed over three climatic zones. The Black Sea District, involving 1.6 million ha, has high rainfall distributed throughout the year and producing high yields. This area covers a large part of East Anatolia (Zone 1). The steppes of Inner, South East and part of East Anatolia include 2.8 million ha of grasslands (Zone 2). The maritime climate of the coasts of Mediterranean, Marmara and Aegean Seas include 6 million ha of grasslands (Zone 3).

High-quality species make up 70 to 80 percent of the swards in Zone 1, while in the steppes of Central Anatolia they amount to only 15 to 20 percent. An attempt is being made to evaluate the various species of the three zones with regard to their importance as feed in order to characterize the swards not only in botanical and ecological terms, but also to determine the feeding value. Pastures in Turkey are overgrazed and thereby production and botanical composition are adversely affected. Practical measures for improvement will be presented.

Key words: grasslands, management, Turkey.

7-2-5 Grass-Legume Mixtures and Fertilization as Factors of the Ecosystem of Cultivated Grassland

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On degraded soils in hilly-mountain regions, natural grasslands are impoverished, low-yielding, and low-quality. While such grasslands yield 1870-2430 kg/ha of dry matter without fertilization and 6040-6800 kg/ha with NPK fertilization, cultivated grasslands are by far more productive.

Experiments conducted from 1971 to 1979 and from 1975 to 1980 in different ecological conditions of the hilly-mountain part of the country, involving 16 grass and grass-leguminous mixtures used for the establishment of cultivated grasslands, showed that it is possible to obtain the yields of 10,184-12,670 kg/ha of dry matter in hilly regions, and 7,940-11,720 kg/ha in mountain regions. Differences in the yields of the examined mixtures were not always statistically significant (LSD 0.05 and 0.01). It was found that the cultivated grasslands with tall grasses and limited number of components, which do not include legumes, were more vigorous and more productive.

Fertilization had a high effect on the examined mixtures, especially on their yields, which ranged from 6,794 to 12,670 kg/ha of dry matter or 72-225% higher than the control. Statistical differences were highly significant at both levels of LSD. One kilogram of NPK nutrients produced 10.84 to 20.00 kg of dry matter, most frequently 13.70 to 18.43 kg.

Fertilization affected considerably the composition of grass cover, participation of plant species and groups, and the quality of herbage.

Key words: cultivated grassland, mixture, fertilization, productivity and quality.

7-3-1

Ecological Energetics at Primary Level in Grazed and Protected Savanna

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Quantitative dynamic studies of incident solar radiation over a grassland, its entry into biotic systems and fractionation into vegetal components and release through litter fall over annual cycle gives a proper perspective of the productive status.

In Chandraprabha sanctuary of the Varanasi Forest Division (India), two sets of savanna stands, one under heavy pressure of uncontrolled cattle grazing (S-2) and the other enclosed by barbed wire fence (S-1), were analysed for incident solar radiation, net energy capture and release through litter fall by the vegetation (predominantly grasses and some shrubs of Zizyphus jujuba). Energy storage and transfer rates of vegetal systems were fractionated into standing live, standing dead and underground parts and litter for herb layer and leaf, branch, bole. Underground parts and litter for shrub layer have been worked out through short-term harvests and energy estimations (bomb-calorimetry).

In protected stands 58.9 x 10^6 kcal/ha/yr, representing 0.9% of the incident solar radiation, goes into net production, of which 18% is shared by Zizyphus jujuba shrubs and 82% by herbs. Net available energy value drops to 35.29 x 10^6 kcal/ha/yr in grazed stand with 0.54% efficiency but shared by shrubs and herbs in the same proportions. About 20 to 25% of net energy production is released by way of litter fall and most of this was decomposed completely within one year (88%).

Primary productive status of this savanna is lower than for most other grasslands of the region. The savanna has withstood a very severe pressure of uncontrolled grazing through a variety of mechanisms including replacement of dominant species and exclosing has led to an increase in primary production of only 40%. This site on a hilly plateau can be satisfactorily used for controlled grazing.

Key words: solar radiation, energy capture, grasses, shrubs.

7-3-2

Climatic Impact on the Forage Production in Tropical Grasslands of Varying Grazing Stress

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Vegetation analysis in terms of response to forage production essentially requires examination of the relationship between plants and the regulating and driving forces of the environment. Some climatic factors will elicit a greater response than others, either alone or when in combination. Therefore to assess the cumulative and individual impact of climatic factors on forage production, a multiple regression equation of the type $Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$ is used to construct a mathematical representation of those abiotic factors which are apparently related to vegetation and which best predict forage production. Such equations are derived for four grasslands of varying grazing stress (viz., zero-grazing-stocking rate 0; light grazing-stocking rate 19 buffaloes/ha; moderate grazing-stocking rate 41 buffaloes/ha; and heavy grazing-stocking rate 50 buffaloes/ha) by using all possible combinations of the five independent variables (% soil moisture, mean air temperature, rainfall, relative humidity and solar radiation), with forage production as the dependent variable. This experiment was carried out on the four grassland sites for one year (1974-75), located within the Vikram University Campus, Ujjain (23°11'N, 75°43'E, msl-490 m) in Central India. Time series data of forage production in terms of aboveground live biomass as dependent variable, when correlated with the time series data of the independent variables, yielded some interesting results. Soil moisture (state variable) at all the four grazing sites and solar radiation (driving variable) at three grazing sites showed a predominating positive contributing factor influencing forage production. Most of the total annual rainfall at the study area falls within four to five months of the year, and soil moisture and solar radiation do not become limiting as they are available for growth throughout the year.

Key words: tropical grasslands, multiple regression equation, forage production, climate, driving variable, state variable, grazing stress.

7-3-3 Climate/Vegetation Relationships in Southwestern North Dakota

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The purpose of this study was to examine the relationship between climate and vegetation at various sites in southwestern North Dakota. The objectives were to determine the best quantitative relationship between precipitation and standing crop at each of 8 sites and to determine if the relationship was similar across sites.

Long-term records of the original quadrat data measuring vegetation production and on-site precipitation were obtained for 7 pastures at the Dickinson Experiment Station, and 1 at the Mandan Experiment Station, North Dakota. Major grasses included one or more of the following: needleandthread grass (Stipa comata), blue grama (Bouteloua gracilis), carex (Carex spp.), Kentucky bluegrass (Poa pratensis). One site was dominated by big bluestem (Andropogon furcatus). Vegetation was protected during the grazing season by cages set out at the start of the grazing season. Correlation analysis was used to determine the most significant relationship between monthly or groups of monthly precipitation and standing crop and regression analysis was used to develop the quantitative relationships.

The results showed that no one month of precipitation consistently predicted standing crop at each site across all sites. Groups of monthly precipitation which spanned the growing season (March through June, April through June) were significantly correlated with yield at each site. On the big bluestem site, standing crop was correlated with precipitation periods which included March and April and months until June, but not with periods of precipitation which started after April. This contrasted with sites dominated by blue grama and needleandthread grass with small quantities of western wheatgrass (Agropyron smithii) and carex. On most of these sites, standing crop was correlated with any group of monthly precipitation from March until July. The fall precipitation (September and October) was never significantly correlated with standing crop at any site--however the fall plus April through June and the fall plus April through July precipitation were each significantly correlated with standing crop at all sites, but one at Dickinson. Precipitation received previous to March was not significantly correlated with standing crop. The correlation coefficient for winter precipitation (November through February) and standing crop was always negative, but not always significant.

Prediction of August standing crop could not be made any earlier than the end of April for any of these sites. Precipitation received prior to the growing season was of little predictive value. When models based on similar independent variables, either individual months or combinations of months, were compared, there were no statistical differences between the slopes of most site models. The implication is that the estimation of kg/ha per cm of precipitation at each site would be similar to all other sites in southwestern North Dakota, however, this is the result of a wide confidence band around the estimation at each site.

Key words: precipitation, vegetation, southwestern North Dakota, predictive models.

7-3-4 Grass and Forb Production on Sprayed and Non-sprayed Mesquite (Prosopis glandulosa Torr.) Dunelands in South-Central New Mexico

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Production of grasses and forbs was measured for four years, beginning in 1976, following aerial application of 2,4,5-T to 3,634 ha of mesquite (Prosopis glandulosa Torr.) dunelands on the Jornada Experimental Range in south-central New Mexico. Plant production was also measured on a 3,318 ha control area. The mesquite dunelands are representative of large areas in the southwestern United States where mesquite has invaded former desert grasslands. Objectives of the study were to determine forage increases attributable to reduced mesquite competition and to evaluate the relationships between production and precipitation.

Both sprayed and control areas were grazed by cattle. Temporary exclosures were used to exclude cattle from three sampling sites on the sprayed and control area each year. The sampling sites were all on sandy range sites with relatively deep soils (>50 cm to caliche layer). A dune-centered sampling system permitted the determination of differences in production on dune and interdune areas. The mesquite dunes, occupying 28% of the land surface, produced more annual forbs and less perennial grasses than the interdune areas. Stem kill of mesquite averaged 56% at sampling sites on the sprayed area. End-of-season harvests are used to compare treatments.

Perennial grass production was 7-, 8-, and 4-fold greater on the sprayed than on the control area in the first three years following treatment, respectively. Maximum perennial grass production of 642 kg/ha occurred in the first season following treatment. In the fourth year the control area received 49 mm more precipitation than did the sprayed area and production of perennial grass was nearly equal on the two treatments. Mesa dropseed [Sporobolus flexuosus (Thurb.) Rydb.] contributed 66-92% of the perennial grass production. Production of annual plants varied widely among years but was greatest in the fourth season when precipitation patterns favored annual plant growth, particularly on the control area where annual forb production was 543 kg/ha. Production of broom snakeweed [Xanthocephalum sarothrae (Pursh) Shinners] cycled from high to low and back to high on both treatments.

Mesquite control is an effective tool for improving forage production on arid rangelands but the success of control efforts depends not only upon the degree of brush kill but also upon the post-treatment precipitation patterns.

Key words: mesquite, Prosopis glandulosa Torr., mesa dropseed, Sporobolus flexuosus (Thurb.) Rydb., 2,4,5-T, forage production.

7-3-5 Population Level Studies of a C_3 and a C_4 Rangegrass in Southeastern Arizona

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C_4 photosynthesis has been shown in the laboratory to be highly advantageous under bright, hot, dry conditions. C_4 (warm season) plants under these conditions are able to gain more carbon and lose less water than C_3 (cool season) plants. Large scale geographic surveys have shown that C_4 species become more numerous in warm, arid environments. The objective of this study was to determine if actual advantages to C_4 photosynthesis existed on the population level.

The study was conducted in the southeastern Arizona grasslands, where there are over 40 species of native C_4 rangegrasses. Only one, New Mexico needlegrass (Stipa neomexicana), is a C_3 grass. The study consisted of a survey of local vegetation patterns, and a large field experiment. The vegetation study showed that the C_3 needlegrass is found not on cool or wet sites, but on dry, exposed ridge crests where total grass cover is low. It reaches its highest cover where the more favorable upper soil horizons have eroded away and a highly calcareous, nutrient-poor C horizon of low water holding capacity remains. Furthermore, it is found in the central, driest part of the valley studied, rather than in the cooler and wetter surrounding foothills.

These ridge crests on which it is found are unfavorable for the needlegrass as well as for the C_4 grasses. However, the effects of competition here are low. It appeared that C_3 grasses might be excluded here, at the limits of their geographic distribution, not by climate but by competition with the C_4 grasses. An experiment was designed to measure competition in different locations in the field. Neighboring plants were removed around target C_3 and C_4 individual bunchgrasses. The C_4 species used was Arizona threeawn (Aristida arizonica), which is commonly found with the needlegrass. Growth was followed. The removals were performed at three locations -- on a ridge crest, where the C_3 was dominant and total cover was low; at midslope, where C_4 species had increased and cover was higher; and on a lower part of the slope, at the border of the C_3 population, where total cover was greatest.

Results confirmed the picture suggested by the vegetation pattern. Both the needlegrass and the threeawn grew best on the lower slope and least on the hill crest. The effects of competition on seedling germination and survival, as well as on the growth of mature plants, was also greatest on the lower slope and least on the hill crest. Competition was most severe during the summer and early autumn when the C_4 grasses in the community were most active. Timing of growth for both species was affected more by competition than by temperature.

These data support the conclusion that the only C_3 rangegrass in these C_4 grasslands is limited in distribution, in seedling germination and survival, and in the growth of mature plants by competition with the more successful C_4 grasses. Plants with C_4 photosynthesis do indeed have population level advantages in this environment.

Key words: competition, C_4 photosynthesis, Stipa neomexicana, Aristida arizonica, warm season grasses, population ecology, species distribution.

7-4-1

Situation and Prospects of Meadow Culture in the USSR

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Meadow culture as a branch of forage production continues to play an important part in the USSR in supplying cattle with cheap and complete feeds. This is favored by vast areas of natural fodder lands situated in many regions of the developed animal husbandry.

In the field of grass growing some theoretical foundations have been worked out and practical recommendations developed for establishing and using highly productive cultivated hay and pasture lands, namely, the most effective methods and rates of irrigation and the optimal levels of fertilizer application on different agrophones have been determined. The results obtained allow the prediction of the effects of soil conditions and fertilizers on the yield of legume-grass stands, the chemical composition and digestibility of the fodder, the productivity and health of the animals and the quality of milk and other animal products. Methods for increasing pasture productivity in arid regions have been revealed and are being widely introduced into practice due to the local zerophytic wild-growing plants. Particular attention is being paid, by the research institutions, to the development of new perennial grasses for all zones of the country. The farms need varieties of perennial grasses that produce high yields of dry matter and seed, that are high in digestible protein and essential amino acids, that are resistant to pests and diseases, that can compete well in grass stands and are long-lived. Under conditions of intensive use of grass stand in areas of cultivated grassland farming, farmers face other problems such as persistence of plants after many cuttings, quick recovery of plants after grazing or cutting, differing times of plant maturity for obtaining uniform development of forage during the growing season. It is also necessary to develop grass mixtures by choosing species suitable for different types and groups of animals and for different methods of use either for hay or for grazing.

Along with the above measures aimed at the improvement of the existing fodder resources, the execution of the programs for increasing the productivity of natural grasslands is of great importance. They are first of all the amelioration of hay and grazing lands, their surface and radical improvement, then higher application of mineral fertilizers, and the development of cultivated pastures, especially irrigated ones. Implementing these measures increases the yield of fodder per unit of area by 2 to 3 times, even higher under intensive culture, and improves its quality. The implementation of these measures allows for decreased feeding of grain to dairy and beef cattle and sheep and releases considerable areas of arable land for production of food and industrial crops. As a result of solving a number of urgent problems connected with the further development of animal industry it is possible to provide the livestock with enough and proper forage.

Key words: meadow culture, forage yield, fertilization, irrigation, animal productivity.

7-4-2 Use of Fodder Production Models for Mineral Soils on Grassland and Arable Land

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In four regions of Poland experiments begun in 1973 and planned to last 12 years compared cutting and grazing yields of permanent grasslands over 20-30 years old to yields of seven field fodder production models. The models had 3-, 4- and 6-year rotations. The experiments were located on mineral soils with 28-50% silt and clay and 2.1-3.5% humus. The water table depth varied from 44 to 170 cm in spring, and 115 to more than 175 cm in summer. Average precipitation during the growing season (April-October) was 375-515 mm and 523-658 mm annually. Average annual fertilization was as follows: N-360, P_2O_5-150, and K_2O-280 kg/ha. Experiments used the randomized block method with four replications of 36 m^2 plots (82 m^2 gross).

Results after eight years showed that the average annual yields of green matter were 54-75 t/ha (t=1000 kg); fodder beet roots 116-135 t/ha; potatoes 30-39 t/ha and broad bean seeds 3.1-3.5 t/ha. Calculated in comparable units, the yields of digestible protein were higher in pastures and meadows (1.6 t/ha) than in the other models (0.98-1.16 t/ha). Yields of starch from meadows were 7.2 t/ha; from pastures 6.0 t/ha; and from field models 5.8-7.6 t/ha. Starch and protein yields calculated in cereal units were 12.7 t/ha from meadows, 11.2 t/ha from pastures, 11.8 t/ha from the highest yielding field model, and 9.6-10.8 t/ha from the other field models. These results showed that permanent meadows and pastures lying on mineral soils and under intensive fertilization and exploitation yielded as much as cultivated fields and still maintained a high level of productivity after eight years of intensive exploitation.

Key words: meadow, pasture, grasses, kale, bean, beets, potatoes, maize.

7-4-3 Productivity and Botanical Composition Response of a Stabilized Pasture to Different Utilization Patterns

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The effect of 3 different utilization patterns upon the productivity and botanical composition of a Chilean southern typical naturalized pasture was studied during a period of a year of growth. The trial consisted of cutting the sward of 3 plots of a naturalized pasture of a perhumid zone in the south of Chile when reaching a height of 20 cm on average, leaving only a height of 5 cm. This process was carried out in 3 plots of 20x20 m using the following methods: plot 1, harvesting with bovines; plot 2, mechanized harvesting with a cutter machine; plot 3, no harvesting but sampling each time the accumulated total of forage during all the period from the start of the trial. The botanical composition of pasture in the 3 plots when starting the experiment was: Lolium spp., 16.4; 12.7; 14.8; Dactylis glomerata, 24.0; 23.6; 18.1; Anthoxanthum odoratum, 0.7; 4.3; 6.2; Oder grass spp., 2.1; 2.3; 1.9; Trifolium spp., 4.5; 2.7; 7.4; wide leaf spp., 12.9; 7.7; 8.9; organic matter, 31.4; 35.9; 37.0; bare soil, 8.0; 10.8; 5.7, in the plots 1, 2, and 3, respectively.

Unimportant variations in botanical composition were observed. Seasonal variations of species are analyzed in the paper. Annual dry matter yield was: 10,442; 10,147, and 9,184 kg per ha in 1, 2 and 3 plots respectively. Seasonal yield variations and the ecological plasticity response of these types of pastures is discussed.

Results suggested that pastures with several species and with a high homeostasis and stability grade can be utilized among a wide range of possibilities without affecting significantly the pasture performance in a year period of growth. This is very important for the farmer of these zones who must face circumstantial changes of management according to environmental and economical seasonal conditions.

Key words: naturalized pastures, botanical composition, pasture management, pasture ecology, humid ecosystems, pasture productivity.

7-4-4

Yield Formation of Perennial Legumes, Legume Grass, and Grass Stands

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The amount of fertilizer, supply of water, and frequency and dates of cutting plants are the main factors which affect yield of grass stands and contribute to quality of fodder.

Research has shown that formation of highly productive grass stands that will withstand multiple cutting should be based on biological features of plant growth and development and creation of conditions for optimum photosynthetic potential and the highest efficiency of photosynthetically active radiation as regards separate cuts and also during the entire vegetative period.

Mass accumulates in perennial grasses from early to later phases of development and during the final period of formation of photosynthetic mechanism. After that the rate of mass accumulation of grass stands is lowered more than three times, and the mass accumulation results from growth of stems.

The highest yield of dry matter, protein and other nutrients is obtained by cutting perennial cereal grasses when mass accumulation rate is lowered.

The greatest effect of fertilizers on the rate of mass accumulation occurs during the final stage of leaf formation. For instance, application of fertilizer during shooting led to increased growth of orchardgrass by 41.6 to 73.5 percent, and during blooming by only 25.0 to 50.1 percent.

The greatest effect of nitrogenous fertilizers on amino acids synthesis is during leaf tube formation, i.e. ear emergence. With fewer cuttings the amount of nitrogenous fertilizers can be increased.

The amount of nonprotein nitrogen, nitrate, deposition is inversely proportionate to the duration of mass formation.

Application of nitrogenous fertilizers at the level of 300 kg/ha resulted in yields of cereal grasses (awnless bromegrass) above 100 quintals of dry matter and 18.2 quintals of crude protein per ha. Alfalfa fertilizer with phosphorus and potassium yielded 75.5 quintals per ha and with nitrogen yielded 100 to 88.0 quintals per ha. A mixture of awnless bromegrass and alfalfa fertilized with 300 kg of nitrogen yielded 100.8 quintals of dry matter and 20.3 quintals of crude protein per ha. Positive balance of phosphorus is obtained with application of 90-120 kg and positive balance of potassium is with 300 kg/ha. High yields of perennial grass for quality fodder requires a balance of nutrients in the soil.

Key words: fertilization, nitrogen, phosphorus, potassium, alfalfa, grasses, yield.

7-5-1

Mortality of Sorgo Plants After Cutting

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Sorgo(Sorghum bicolor Moench) is usually harvested twice a year in Japan, and three times in the southern part. Some sorgo plants cannot regrow and die after cutting, which leads to low aftermath yield. The authors have been studying this death of sorgo plants for three years. The purpose of this study is to clarify what cultural factors cause death and what plants die in the sorgo community.

Three field experiments were carried out from 1977 to 1979, to investigate the effect of the sowing date, planting density, nitrogen(N) level, and cultivar on the mortality rate after cutting. In 1979, to investigate the effect of high temperature on mortality, sorgo plants which had received cutting treatment were grown in growth chambers set at 35/30°C,30/25°C, and 25/20°C day(12 hours)/night(12 hours). In order to obtain information about what plants die, plant characters of all the plants within $1m^2$ (2 repetitions) in the sorgo community were recorded at cutting time in 1979. The regrowth after cutting was also recorded. Correlation and multiple regression analyses were done.

The mortality of the sorgo community after cutting was found to increase when plants received cutting treatment at too early a stage of growth. The mortality became higher as the density was increased, and as the N level was increased. There were significant differences in mortality between cultivars. The high mortality of cultivars was closely related to lateness and low Brix. The light extinction curves within the canopy did not always explain the high mortality of cultivars. The growth of sorgo after cutting,in terms of yield, became more vigorous as the temperature was increased. Therefore, it was impossible to consider that a high temperature in natural conditions in the experimental site could be responsible for high mortality. Almost all the dead plants belonged to the lower classes of frequency distributions of plant length, plant yield, and Brix. They also belonged to the higher classes of N content. Positive correlations were found between plant length, plant yield, and Brix. N content was found to correlate negatively with these characters. The multiple regression equation, where yield of regrowth was a dependent variable, and plant yield, Brix, and N content were independent variables, accounted for 92% of the variation. The linear regression equation, where yield of regrowth was a dependent variable, and plant yield was an independent variable, accounted for 90% of the variation. It was considered that the linear regression equation explained the relation just as well as the multiple regression equation.

In this series of investigations, we were able to identify the cultural factors affecting the mortality after cutting in the sorgo community. Results of the correlation and multiple regression analyses gave us new knowledge about the behaviour of individual plants in the crop community receiving cutting treatment.

Key words: sorgo, Sorghum bicolor Moench, mortality, Brix, regrowth, multiple regression analysis.

7-5-2 Factors affecting Cyanogenesis in White Clover (Trifolium repens L.)

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Populations of white clover (*Trifolium repens* L.) from the warmer limits of its climatic zone normally contain a high proportion of cyanogenic individuals. These plants release hydrocyanic acid (HCN) when eaten by ruminants but are rarely, if ever, toxic presumably because the high sulfur content of the plant ensures ready detoxication of HCN by the formation of thiocyanate. It is postulated that thiocyanate, a confirmed goitrogen, is a causal factor in the sporadic outbreaks of neonatal goitre reported in sheep grazing white clover. We used controlled environment cabinets to determine the effects of age, light, temperature, nutrition and wilting on the HCN potential (HCNp) of white clover.

Experiment 1. Clones from cyanogenic white clover plants were established in 96 pots containing 1.7 L of low fertility soil, and the plants were grown for 68 days at 21°C day/14°C night temperatures and harvested. The following treatments were then applied in a nested factorial arrangement. N - ammonium nitrate equivalent to 0, 75 or 150 kg N/ha; P - $NaH_2PO_4.2H_2O$ equivalent to 0 or 30 kg P/ha; light - 96 or 227 µEi/m/sec for 16 h/d; temperature - 14/9 or 22/17°C. Regrowth was harvested after 30 days. In Experiment 2, six plants/pot were established from seed (cv Huia) in 72 pots (1.7 L) and grown for 66 days at 21/15°C before harvesting. Regrowth was harvested after 19, 33, 46, 60, 74, 95, 116, 137 and 159 days. Half the pots to be harvested on each occasion were moderately wilted by witholding water for 2-4 days. All samples from both experiments were analysed for HCNp.

HCNp, adjusted by covariance for pre-experimental HCNp, was reduced by higher light intensity (51 vs 22 mg HCN/100 g DM; $P < 0.001$), by increased temperature (41 vs 32; $P < 0.05$) and by P application (38 vs 34; $P < 0.05$). The combination of low light, low temperature, and poor P status gave a mean HCNp of 61 mg HCN/100 g DM while higher levels of each of these factors gave a mean of 20 mg HCN/100 g DM. These effects may be explained by the hypothesis that HCNp diminished as the size and vigour of the plant increased: use of DM production as a covariate on HCNp removed the significant effects of light, temperature and P.

In Experiment 2 plant age rather than weight accounted for most variance in HCNp; as the plants aged HCNp declined curvilinearly (HCNp (mg/100 g DM) = $37.9 - 0.53\ d + 0.002\ d^2$; $P < 0.001$; $R^2\% = 76$; d = days of regrowth). Wilting plants prior to harvest (moisture content 69% vs 79% in controls) increased HCNp (11 vs 14 mg/100 g DM; $P < 0.001$) and reduced DM yield by 9%.

The conditions shown to favour high HCNp, namely immaturity, moisture stress, low light intensity, cool temperatures, and inadequate P supply, occur periodically in late autumn and early spring in temperate climates. Thus sheep in late pregnancy at this time, could, if white clover comprises a substantial proportion of their diet, experience appreciable thiocyanate absorption and hence increase the risk of goitre in the lamb.

Key words: white clover, HCN potential, wilting, nutrients, age. light, temperature, goitre.

-5-3 Relationships Between Grass Tetany and Aluminum and Manganese in Soils, Plants, and Animals

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The etiology of hypomagnesemia or grass tetany of ruminant animals is not well understood. Although it is sometimes due to low magnesium (Mg) intake, several mineral imbalances may interfere with Mg utilization by ruminants. The objectives of this study were to identify mineral imbalances associated with grass tetany and describe the soil-plant-animal relationships under which they occur.

Mineral levels in soils, forages, rumen contents, and blood serum were investigated during grass tetany outbreaks in Louisiana. Total concentrations of Mg, calcium (Ca), potassium (K), phosphorus (P), sodium (Na), zinc (Zn), and manganese (Mn), although variable, were generally within acceptable limits in soils, forages, and rumen contents. However, high concentrations of aluminum (Al) were found at all tetany sites. Forages commonly contained 2,000 to 8,000 ppm Al and rumen content samples from dead tetany animals averaged 1,900 ppm Al.

High soil moisture and low temperatures followed by a temperature rise above 14 C have been associated with grass tetany by other investigators. Our studies indicate forages accumulate Al in response to those factors. Forage Al concentration significantly increased with soil moisture level at tetany sites (r=0.62**). Ryegrass (*Lolium multiflora*, Lam.) grown on ponded soils in a greenhouse contained significantly higher concentrations of Al and Mn and lower concentrations of Mg and Ca than grass grown on drier soil ($P \leq 0.05$). Plants exposed to 0-3 C in growth cabinets accumulated more Al than plants exposed to 8-12 C. In field studies, ryegrass grown under ponded conditions accumulated over 1,000 ppm Al following a rise in soil temperature above 14 C, while grass grown on well-drained sites accumulated less than 500 ppm Al.

In vitro and *in vivo* studies indicated that Al reduced the availability of Mg and Ca to ruminants. Additions of 8,000 ppm Al to *in vitro* digestion tubes reduced the solubility of Ca and Mg by 74 and 56%, respectively, after a 48-hour incubation period. Fistulated steers treated daily with 4,000 ppm Al showed depressed serum Mg levels within 24 hours after treatment began, and the levels declined approximately 32% during the four-day period ($P \leq 0.01$). After Al treatments were discontinued, serum Mg levels increased and were no lower than controls three days later. Serum Ca levels were not affected by Al treatments. Additions of Mn to the rumen had no significant effect on serum Ca or Mg.

An investigation of a tetany outbreak in animals fed ryegrass hay revealed Al concentrations in the hay ranging from 100 to 8,000 ppm. Although total Mg was similar for all hay, the water-soluble Mg fraction averaged 32% less in high Al hay samples. Total Al was negatively correlated with water-soluble Mg (r= -0.97**). In a tetany-prone pasture total Al was highly correlated with the Mg fraction that was insoluble in concentrated hydrochloric acid (r= 0.98**). These results show a very strong relationship between high forage Al concentrations and the occurrence of grass tetany.

Key words: hypomagnesemia, grass tetany, aluminum accumulation, ruminant nutrition.

7-5-4

Presence of Pinitol in Various Legumes: Its Effect on Forage Quality and Animal Metabolism

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Inositol methyl ethers have been known to occur in plants for many years. However, until the recent availability of improved chromatographic techniques, they were not considered to be major constituents of forage legumes. Using procedures developed in our laboratory we found 1D-3-0 methyl chiro-inositol (Pinitol) to be a major constituent in the foliage of many legumes. Therefore, research was conducted on the physiological function of pinitol and its influence on forage quality and animal metabolism. For studies involving plants, various cultivars of alfalfa, red clover, white clover and birdsfoot trefoil were employed. Duplicate samples from each harvest were extracted with 80% ethanol, and analyzed for pinitol content by GLC. Albino rats and meadow voles (Microtus pennsylvanicus) were employed for metabolism studies in animals. Pinitol was fed at 4-10% level and feces, urine and various organs were analyzed.

Data on pinitol concentration in the cultivars of alfalfa, red and white clover indicated a minor but significant difference among species. But probably of greater significance was the high pinitol concentration relative to sucrose in the foliage of these species. Its concentration was nearly equal to sucrose in red clover and birdsfoot trefoil, and nearly half as much as sucrose in alfalfa and in white clover. In greenhouse-grown plants, pinitol content was similar to sucrose in leaf and stem tissues but it was 4 - 8 times higher in foliage than in the root. It was also observed that plants grown in greenhouse contained in addition to cyclitols, considerable quantities of fructose, glucose and sucrose, but as the plants matured, sucrose and pinitol were the major soluble carbohydrates in these plants. Also, pinitol content was found to be unaffected by prolonged periods of darkness, indicating that it did not function as energy reserve readily available to plants.

The results of feeding trials revealed that pinitol did not affect the feed intake in meadow voles. Feed efficiency was slightly decreased in rats fed pinitol at 10% level compared to sucrose controls (1.9 g feed/g wt gain vs 1.5 g feed/g gain, respectively). Preliminary data from the metabolic trials indicated that pinitol was metabolized by both species of animals. Results of the in vitro digestion of pinitol by rumen microbes also showed that it was degraded by the rumen microbes. The gross energy value of pinitol was found to be 4.1 Kcal/g compared to 3.8 Kcal/g of sucrose.

Since pinitol is a major constituent in foliage of many legumes, it must be considered important for forage quality and research in this area is being further pursued.

Key words: pinitol, 1D-3-0 methl chiro-inostol, significance, function, plants, rats, meadow voles.

7-6-1

Seed and Seedling Dynamics of Annual Medic Pastures in South Australia

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Annual species of *Medicago* (i.e. medics) are the key to successful cereal-pasture rotations in the integrated crop-livestock farming systems on the neutral to alkaline soils of southern Australia. However, many medic stands have deteriorated in recent years. This has prompted research on the effects of grazing sheep on the seed-seedling dynamics of annual medic-based pastures in the Mediterranean environment of South Australia and to quantify the impact of medic seed reserves in or on the soil upon pasture establishment and productivity.

Animal house experiments involving the feeding of pure-pod and pod-chaff diets to sheep, and a field experiment have been used to measure the survival of medic seed following the ingestion of intact pods. In farm survey and sampling studies total seed reserves of annual medic species following cereal crops have been related to medic emergence and establishment, total pasture yield and botanical composition.

In the field experiment on red brown earth soil of the Waite Institute there was a highly significant linear decline in total pasture, medic pods and medic herbage (r=-0.998***, -0.992*** and -0.997***, respectively) over a 56-day period of continuous grazing by Merino wether sheep. Over the same period there was a highly significant linear decline in pod number/m^2 (from 4167 to 619), pod weight (from 54.5 to 46.9mg), seeds/pod (from 6.86 to 4.53) and seed weight (from 2.87 to 2.54mg). Viable seeds/m^2 declined dramatically (r=-0.987***) from 23715/m^2 on day 0 to 2652/m^2 on day 56. Medic seed extraction from the sheep faeces showed a highly significant linear decline in seed throughput from 6155 to 3251 viable seeds/sheep/day and mean seed weight from 2.91 to 2.60mg during the 56-day period.

The survey data from farms on solonized brown soils showed medic seed reserves in April varying from 16 to 282 kg/ha (mean 106.3). The mean emergence count at the end of April was 239/m^2 which population declined to 141/m^2 by the beginning of June. There was still some emergence in July, giving a mean establishment of 188/m^2 (range from 2 to 490/m^2) which was only 60% of the mean cumulative emergence of 313/m^2. The mean seed reserve in September had declined to 66.2 kg/ha with a negligible change in mean seed weight from 2.805mg in April to 2.852mg in September.

These studies have shown conclusively that grazing sheep may seriously deplete potential medic seed reserves and that this may result in grossly inadequate seedling density. Medic seed reserves in the top 5cm of soil are a reliable indicator of potential density and productivity of medic pastures. For this reason core-sampling techniques are being developed to enable farmers to assess their needs for sowing additional medic seed before the autumn rains.

Key words: annual medics, *Medicago spp.*, pods, sheep, seeds, emergence.

7-6-2

Establishment of Grasses on Cracking Clay Soils: Seedling Morphology Characteristics

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Although native grasses establish readily on the cracking black clay soils of north western New South Wales, Australia, it has proven difficult to establish introduced summer grasses. Young grass seedlings were examined to see if morphological differences existed which may explain their differing capacities for establishment.

It has been shown that relative differences in the primary and secondary root growth of various species can have important effects on the agronomic characteristics of those species. Low soil moisture conditions near the soil surface will restrict greatly or possibly even prevent the growth of secondary roots of young seedlings. It is well known that the surface layers of this particular soil type dry out very rapidly following rain.

Seedlings of four native and four introduced grasses were grown under favourable conditions, then destructively sampled 3, 4 and 5 weeks after planting. A number of morphological characteristics were examined including:- wt. top growth, wt. root growth, length and wt. of primary and secondary roots.

There was considerable variation among the species both in respect to the amount of growth and the type of growth. Generalising, the following trends were evident:

1. The native species tended to have smaller seedlings.
2. The native species had lower ratios of wt. top growth to wt. root growth.
3. The native grasses had much higher ratios of wt. primary root to wt. secondary root.

Given that secondary root growth is very likely to be restricted by soil surface drying, it would seem the native grasses overcome this by having a better developed primary root and a lesser developed secondary root system. As well they have a lower ratio of top growth to root growth so that the roots should be better able to supply the plant during periods of moisture stress.

The work suggests that selection of introduced species for use on this soil type should be made on the basis of well developed primary root systems and a low ratio of top growth : root growth.

Key words: establishment of grasses, seedling morphology, primary roots, secondary roots, cracking clays.

7-6-3 Legume Establishment in Grass-Dominant Swards: Concept and History in Kentucky

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Grassland farming has been practiced for two centuries in central Kentucky, and for shorter periods in other parts of the state. Savannas and tallgrass prairies were severely grazed by domestic animals and row-cropped by early settlers, destroying most of the indigenous plant species. By the early part of the 19th century, beef cattle were being produced on bluegrass, Poa pratensis L., pastures, and driven on foot to east-coast markets. During the first century of settlement, farmers learned to top seed legumes into grass sods, and in the course of the last hundred years, development of grassland technology for establishing legumes into grass-dominant swards has slowly and steadily improved. Highlights of research leading to current concepts of establishing and exploiting legumes in grass-dominant swards are given. Stand maintenance of birdsfoot trefoil, Lotus corniculatus L., and bigflower vetch, Vicia grandiflora var. kitaibeliana W. Koch, through periodic natural reseeding is suggested.

Key words: grassland renovation, cool-season grasses, top seeding, minimum-tillage, natural reseeding, overseeding.

7-6-4

Mefluidide as a Grass Growth Suppressant in Pasture Renovation

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The improvement of tall fescue (Festuca arundinacea Schreb.) pasture through renovation with legumes is a commonly accepted practice throughout the region of adaptation of tall fescue. A number of techniques for introduction of the legume and suppression of grass competition have been reported with varying degrees of success. The primary objective of this study was to determine the feasibility of using the growth retardant mefluidide (N-[2,4-dimethyl-5-[[(trifluoromethyl)sulfonyl]aminol]phenyl]acetamide) as an aid to the establishment of alfalfa (Medicago sativa L.) and birdsfoot trefoil (Lotus corniculatus L.) and to evaluate the impact of nitrogen fertilization.

Mefluidide was broadcast at a rate of .56 kg/ha on 29 March and/or 15 May. Alfalfa and birdsfoot trefoil were sown at 11.2 and 5.6 kg/ha respectively with a power-till seeder on 11 April. Nitrogen was broadcast at 30 kg/ha on 19 April and 50 kg/ha on 7 May following the first harvest.

The early application of mefluidide resulted in a 52% decrease in grass yield in the first 38 days following treatment and an 18% increase in grass yield in the following 28 day growth period. When mefluidide was applied later in the season, grass yields were reduced by 66%, 20 days after application. Split applications of mefluidide suppressed grass growth by 53% over the entire 66 day period. Total annual reduction in grass yield was 18%, 7% and 25% for early, late and split application of mefluidide.

Legume seedling populations were determined 60 days after seeding. Mefluidide treatments resulted in higher seedling populations. A 12%, 16%, and 26% increase in number of seedlings/m^2 was recorded for the early, late, and split treatments respectively. Alfalfa seedling dry weight at 60 days increased from .08 g to .12 g when grass growth was suppressed by late applications of mefluidide. Trefoil seedling weights were about .06 g for all treatments.

Trefoil exhibited a higher degree of tolerance to nitrogen fertilization than alfalfa. Control plots had 82 and 113 plants/m^2 for alfalfa and trefoil respectively. Nitrogen fertilization reduced stands to 31 and 60 plants/m^2. Early applications of mefluidide resulted in stands of 93 and 94 plants/m^2. Nitrogen fertilizer in conjunction with early application of mefluidide produced populations of 46 and 93 plants/m^2 for alfalfa and trefoil respectively. Seedling weights were not affected by nitrogen fertilizer, although the dry weights of nodules was reduced 35% by N-fertilization.

Key Words: tall fescue (Festuca arundinacea Schreb.), melfuidide, growth Regulator, alfalfa (Medicago sativa L.), birdsfoot trefoil (Lotus corniculatus L.), pasture renovation.

7-7-1 Effect of Treading and Return of Excreta on a Perennial Ryegrass/White Clover Sward Defoliated by Continuously Grazing Sheep

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The grazing sheep may affect the association between grass and clover in a mixed sward by defoliation, treading and the circulation of nitrogen (N) via excreta. An understanding of the relative importance of these components of the grazing process is required when formulating grazing management principles for grass/clover swards. Our objective was to examine the effect of treading and excreta on a perennial ryegrass (Lolium perenne)/white clover (Trifolium repens) sward defoliated by sheep at high and low stocking rates.

Established perennial ryegrass/white clover swards were continuously stocked from May to October with yearling wether sheep at 25 and 50 ha^{-1}. Sward production and species composition was measured inside 'graze-through' cages which allowed defoliation without treading and excreta return, and outside, where sheep grazed either fitted with harness to prevent the return of excreta or unharnessed to allow the normal return of excreta.

Herbage production from the defoliated sward was estimated at 5.42 and 8.99 t DM ha^{-1} at high and low stocking rate respectively. Treading reduced this by 10% at high stocking rate ($P < 0.05$), and 4% at low stocking rate ($P > 0.05$). The return of excreta increased herbage production by 53% at high stocking rate and 26% at low stocking rate.

At low stocking rate, treading had little effect on botanical composition. Without the return of excreta, clover content increased from about 58% at the start of the experiment in spring to about 71% in autumn. The return of excreta at this stocking rate reduced clover to 45% in autumn. The quantity of clover (kg/ha) present at the end of the experiment was higher than at the beginning in the treatments both with and without excreta return; the reduction in the percentage of clover where excreta were returned was primarily the result of an increase in the quantity of ryegrass present. Measurement of clover stolon changes showed that where excreta were returned, there was little change in stolon length, but where excreta were not returned, there was a substantial increase in stolon length.

At the high stocking rate, the percentage of clover on offer in autumn was 31% in the defoliated sward, 25% where this sward was trodden and 18% where excreta were returned. Clover stolon length declined during the grazing season in all treatments, with the decline being greatest where excreta were returned.

In conclusion, at a stocking rate where treading by continuously grazing sheep had a negligible effect, N transfer via excreta significantly increased herbage yield and reduced the proportion of clover in a grass/clover sward. At a higher stocking rate, herbage yields were depressed and the benefits of increased N transfer via excreta were outweighed by the detrimental effects of increased defoliation and treading.

Key words: perennial ryegrass, Lolium perenne, white clover, Trifolium repens, defoliation, treading, excreta return, sheep.

7-7-2 Performance of a Subtropical Legume-Grass Pasture Under Different Grazing Management Systems

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Agronomic evaluation of the dynamics of tropical legume-based pastures is relevant in assessing the response of their components within systems of grazing management. The response of tropical legume-grass mixtures to levels of days rest and grazing pressure, and which combination will result in meaningful legume content in the mixture, needs to be known.

A central composite design was used to study the performance of a Desmodium intortum (Mill.) Urb. and Paspalum guenoarum Arech. pasture mixture to 14, 28, 42, 56 and 70 days of rest combined with 2.0, 3.5, 5.0, 6.5, and 8.0% B.W. as grazing pressure, in a rotational grazing system. Forage DM yield and botanical composition were assessed by double-sampling procedure. Pasture parameters were analyzed by a second degree polynomial; canonical analysis facilitated the interpretation of pasture performance.

Daily pasture LM yield and P. guenoarum and D. intortum percentage increased with longer periods of rest. None was affected by grazing pressure. However, the invasion of other grasses increased with short periods of rest and higher grazing pressure. The weed component was present at very low levels. Stocking rate increased with increasing grazing pressure. Forage consumption tended to increase under lenient grazing pressure and also at long periods of rest. P. guenoarum and D. intortum assure good quality feed even at long periods of rest.

Long rest periods are required if D. intortum and P. guenoarum are to be maintained as active components of the pasture, effectively contributing to forage feeding systems in the tropics.

Key words: Paspalum guenoarum Arech., Desmodium intortum (Mill.) Urb., grazing systems, days rest, grazing pressure, botanical composition, stocking rate, IVOMD.

7-7-3

Effects of Management on Recovery of Water-Stressed Ryegrass

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On droughty soil in New Zealand, a study over three years was made of the effects of summer grazing managements with sheep on the recovery of 'Grasslands Nui' ryegrass-white clover pasture in autumn. These managements followed set-stocking with ewes and lambs from August to late November and thereafter were; no grazing over 90 days, or set-stocking during that period, or grazing in rotation over three sub-divisions of pasture at 5 days or 15 days interval. None of the grazing treatments had consequential deleterious effect.

Earlier controlled environment studies with sparsely flowering plants of Nui ryegrass under water stress and with a leaf clipping treatment are compared with later studies with profusely flowering plants and either culms clipped or alternatively leaf clipped twice. This was to provide conditions relevant to the field study and thus an understanding of the ways in which grazing managements might influence plant processes in water stress and recovery. The only common result in these controlled environment experiments was tillering subsequently reduced by clipping effects in water stress. Growth rates of tissues of profusely flowering plants in rewatered recovery were generally enhanced by previous clipping. Water stress in controlled environment together with a double leaf clipping treatment differentiated between ryegrass varieties with known drought tolerance or susceptibility.

The lack of grazing management effects during summer drought on subsequent growth in autumn of Nui ryegrass pasture, is interpreted as a failure to influence growth of grass already flowered and drying off in drought. It is suggested that management treatments, if applied earlier, could have effects through influencing flowering control of tillering.

Key words: perennial ryegrass, *Lolium perene* L., drought grazing, recovery growth, water stress, controlled environment.

7-7-4

Mathematical Models of Retrogression of Forage Species Population Under Grazing Conditions in the Stipa Steppe

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In the region of Northwestern China there are about eight Stipa constructive species which form various communities of Stipa Steppe. In this paper, the authors take Stipa breviflora + Agropyron cristatum + Artemisia frigida association as a typical example and make use of the method of mathematical analysis in an attempt to build up mathematical models which may explain the rule of succession of this type by means of mathematical language. Coverage is employed as an indicator in representing the dominance of the population species.

In the moderate grazing stage, accompanying an increase in successive grazing, the dominance of the constructive species Stipa breviflora declines by degree and the curve of the population can be indicated by the equation $P=87e^{-0.74T}$. Agropyron cristatum, a subdominant in the original community, appears as a dominant species in the second stage, but after this, the dominance of its population drops down gradually and the curve can be expressed by the equation $P=12T^{2.7}e^{-0.3T^2}$. Artemisia frigida, a companion species in the incipient community, gains the status as a dominant in the heavy grazing stage. Prior to this, its dominance exhibits a progressively rising curve which can be indicated by the equation $P=5.38e^{0.4T}$, yet when $T > 3$, the curve declines as $P=148.16^{-0.46}e^{0.17T^2}$. Convolvulus ammannii, an accidental in the first stage or an exotic species shows a slow increase in its population before the excessive grazing stage and the equation in the section of the rising curve is expressed as $P=0.745e^{0.45T}$, but as $T > 4$, the population degrades abruptly and exhibits as the equation $P=12T^{2.7}e^{-0.3T^2}$. The community is now approaching a secondary bare area.

As a whole, the retrogressive succession of the Stipa Steppe range shows a total characteristic curve of retrogression in its populations due to over-grazing. The curve can be represented by the equation $\bar{P}=132.9e^{-.89T}$. It has been discovered that all populations of species arrive at a critical condition at the fourth stage, and there, the incipient community entirely loses its general nature and it is said to be a heterogeneity community or disclimax. The critical straight line (curve) can be shown by the equation $P=1.1302T$. And under this critical situation, the total coverage of populations in the community is about 4.5%. At this point, we give the dominant Convolvulus ammannii of the community the name of "critical indicative species."

Key words: grazing succession, mathematical model, Stipa Steppe, pasture productivity.

7-8-1

Pattern of Defoliation by Cattle Grazing Crested Wheatgrass Pastures

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Utilization of a monotypic stand of perennial grass by cattle is generally assumed to be a random process that can be adequately measured by counting the number of plants grazed or by comparing biomass on caged and grazed plots. At a similar level of approximation, grazing is often simulated experimentally by clipping down to a prescribed height. The purpose of our study was to examine defoliation in more detail, following grazing severity and frequency on an individual plant basis with an interval of only 48 hours between observations.

The foothill ranges of Utah provide critical forage resources between winter and summer grazing lands. In the Intermountain region, these sites naturally vegetated with sagebrush, grass and juniper trees are frequently converted to improved ranges by clearing the brush and planting introduced grasses such as crested wheatgrass (Agropyron cristatum(L.) Gaertn.), which is more productive and more resistant to spring grazing than the native grasses. The study was conducted on two 28-ha pastures of crested wheatgrass, originally seeded 25 years earlier, in a semi-arid area (320 mm annual precipitation) located in west-central Utah, 8 km southwest of Eureka. Nearly 300 permanent plots ($0.5m^2$) were involved in the project.

During six weeks of grazing by cattle in June and early July, 1979, the overall utilization was 46 percent by volume, with nearly 70 percent of all plants being grazed at least once. Only one-sixth of the grazed plants was defoliated on more than one occasion, and most of those were grazed just twice. Chi-square analysis indicated a preference for moderate-sized plants, with less intensity of grazing on the very small or largest size classes. Sixty percent of the smallest size class plants was not grazed at all. For those plants that did experience defoliation, severity of grazing was inversely related to plant size.

Grazing on these crested wheatgrass pastures is neither random nor uniform. The results demonstrate that the cattle removed forage in a fashion that varied depending on size class. Very small plants were grazed in a manner similar to a clipping simulation. Wheatgrass plants greater than 200 cm^2 basal area experienced a loss of less than half the plant volume impacting less than half the plant cover, at an average defoliation event. The preponderance of biomass remaining in the large 'wolf' plants at the end of the grazing period would suggest that estimating utilization by departure from amount of forage protected in ungrazed cages could underestimate actual utilization on the population of plants providing most of the consumed forage.

Key words: crested wheatgrass, Agropyron cristatum (L.) Gaertn., utilization, cattle, grazing pattern, defoliation frequency.

7-8-2 Consumption Rates of Desert Grassland Herbivores

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Studies were conducted on a desert grassland range in southern New Mexico for three years to determine relative consumption rates of the main herbivores utilizing these range areas. Consumption of some groups (cattle, pronghorn and rabbits) was determined from direct estimates of intake per individual and density as determined from censusing procedures or known stock rates. Consumption of other groups (birds, rodents, and invertebrates) was determined from census information relating to age structure of the population and metabolic rate. Consumption by all herbivores averaged less than 5% of the above ground net primary productivity for the three years of the study. Highest consumption rates among the herbivore groups were for cattle which consumed an average of 4.3 $g \cdot M^{-2}$ during the study. Consumption by rodents was fairly high during the first year of the study when rodent densities were high, but declined during the second and third year in response to declines in rodent densities. In contrast, invertebrate consumption was highest during the third year of the study and actually exceeded that of rodents. Precipitation was favorable during the third year of the study and was reflected by the high aboveground net primary productivity that year. Apparently, invertebrate populations responded more quickly to favorable plant growth than rodent populations. Consumption rates of pronghorn antelope, rabbits and birds were relatively small. Rabbit consumption was nearly constant during the study period. Density of breeding bird populations was fairly low although large build-ups of migrant bird populations occurred late in the third year of the study. Energy flow to the herbivore populations was also small compared to aboveground net primary productivity. Total energy transfer to herbivores was only 24.3 $Kcal \cdot M^{-2}$ compared to 593 $Kcal \cdot M^{-2}$ calculated for aboveground net primary productivity. Large herbivores, including pronghorn antelope and cattle, contributed most of the energy transferred during herbivory followed by small mammals, invertebrates, birds, and rabbits. From the standpoint of range productivity, it appears that a relatively small portion of energy fixed by plants is harvested by man in the form of animal products. There appears to be a large, untapped source of energy on our rangelands which has the potential to be converted to food for a hungry world. How best to make use of this resource and still maintain stable ecosystems is a challenge facing range researchers and users.

Key words: consumption rates, desert grassland, herbivores.

7-8-3 The Serengeti Ecosystem: A Mechanistic Analysis of a Highly Productive, Natural Ecosystem

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The Serengeti ecosystem, operationally defined by the annual movements of large migratory herds of wildebeest, is a mixed grassland-savanna mosaic in Tanzania's Serengeti National Park and Kenya's Masai Mara Game Reserve. This region of over 25,000 km^2 is one of the last extensive, unmanaged grazing ecosystems. The ungulate biomass residing there is the largest in the world with over 3 million head of 25 species. We report ongoing research in this ecosystem aimed at producing an operationally based model incorporating plant physiological and morphological parameters with ecosystem level parameters such as rainfall and herbivore movements.

Feedback processes have been identified as mechanisms for maintaining the plant production necessary to support such a large herbivore biomass. Productivity of stands with an adequate water supply is stimulated optimally when grazers remove approximately half of the standing crop. The patchiness of community structure and rainfall allow herbivores to move between stands of various physiological conditions, palatability and productivity.

Our ongoing work is centering on defining the mechanisms of productivity stimulation in each of the three different functional grassland types in the Serengeti using gas exchange methodology. This mechanistic understanding of plant response to herbivory is incorporated into an ecosystem level model. At the producer level, we define three major ecosystem compartments and the environmental parameters which regulate them. The residual plant biomass left following grazing is a function of water availability. Actual yield to grazers is a function of nitrogen (N) availability with higher N levels resulting in more herbage available to grazers. Plant litter is an ecosystem level component, yield to decomposers, and is a function of the height at which the plant is grazed. Less intense offtake by grazers results in more plant biomass available to decomposers. The resulting high carbon:nitrogen ratio in the soil feeds back to both the producer and grazer compartments in terms of N availability.

The long coevolutionary history of this ecosystem has resulted in the development of many of these intricate causal networks. In our attempts to manage such ecosystems we short-circuit some of these networks. We are endeavoring to define the operations of a natural ecosystem in detail sufficient for application in managed grazing ecosystems.

Key words: Tanzania, Serengeti, ecosystem model, productivity stimulation

7-8-4 Fertilization and Grazing Experiments in Iceland

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Icelandic rangelands play a very important role in the agriculture of the country, which is primarily based on meat and dairy production from herbivores. It is estimated that nearly half of the roughage consumed is derived from natural rangelands. They are however in a bad state due to erosion, reduced plant production and quality. This has been caused by deteriorating climate, volcanic activities and prolonged overgrazing.

The objectives of the experiments in discussion were to study the effects of fertilizer application on the botanical composition, yield, carrying capacity, nutritive value of herbage, and livestock gain.

Different amounts and combinations of N, P, K were applied to different plant communities at 30 locations with highly variable growth conditions as regards soil types, elevation, etc. The fertilization trials were carried out in the years 1967 to 1979. Plot size was in most cases 30 m^2 and each treatment was replicated two or three times. Measurements of yield and botanical composition were done annually.

Results from 7 grazing experiments conducted 1975 to 1979 on both fertilized and unfertilized pastures are presented. Sheep and cattle were used in the experiments, both separately and in mixed grazing. Botanical composition was measured once a year during the grazing period while plant yield estimates and weighings of the animals were in most cases done with three-week intervals. The size of the experimental areas varied (in 1978) from 37 to 259 hectares, number of pastures from 4 to 18 and number of animals from 38 to 138.

The fertilizer effects were highly variable, depending on growth conditions and plant communities. Generally, however, an application of N and P together resulted in a great increase in grasses and cover density. After two to three years of fertilizer application, grasses had become dominant on most sites. When this vegetational change had taken place an application of 80 kg N and 35 kg P per hectare resulted in five- to ten-fold increase in yield. N or P alone seldom resulted in yield increase or caused any considerable vegetational change. In order to maintain the increase in cover, grass density and yield an application every second or third year seems to be required under proper grazing.

In the grazing experiments, comparisons were made between three to six stocking stages on both fertilized and nonfertilized pastures during a grazing season of 70 to 110 days.

Fertilization resulted in two- to eight-fold increase in carrying capacity, depending on site, which is somewhat less than reflected in the yield increase. In general there was not much difference in gain per head between the fertilized and nonfertilized pastures. The main reason for this may be that the pastures were grazed continuously throughout the summer.

It is clear that some kind of rotational grazing or another form for grazing management is needed to maximize the output of the fertilization, especially in the lowlands.

Key words: nitrogen, phosphorus, potassium, fertilization, grazing, yield, animal gain.

7-8-5 A Comparison of Fertilization and Interseeding on Native Mixed Grass Prairie in Western North Dakota

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The application of plant nutrients (fertilization) and the introduction of seed into an established vegetative cover (interseeding) are two important range improvement practices. Much work has been done to evaluate the effect of these improvement practices on different vegetative communities.

In 1969 a study was undertaken at the Dickinson Experiment Station, Dickinson, North Dakota to evaluate the forage production and species composition changes effected by the application of various rates of fertilization and by interseeding different species of grasses and legumes. The study site was located on silty loam soils supporting a native mixed grass plant community.

The fertilization study consisted of a randomized block design with 12 treatments, three replications, and plots measuring 9 x 30 m. The treatments included various combinations of nitrogen (N), phosphorus (P), and potassium (K), nitrogen and phosphorus alone; heavy one-time nitrogen applications; and alternate year nitrogen applications. The interseeding trial consisted of a randomized block design including 11 treatments, three replications, and plots measuring 15 x 46 m. The treatments included interseeding five grasses and five legumes, and the check plowed where the machine was used but nothing was seeded. Both studies included a check (or control) treatment.

Average forage production for the 8-year trial was highest for the treatment fertilized with 56 kg/ha P and 75 kg/ha N every year, which produced 3584 kg/ha. This was not significantly different ($P < .01$) from the Ladak, Travois and Vernal alfalfa interseeded or those receiving annual application of 112 kg/ha N treatments.

The Ladak, Vernal and Travois alfalfa interseeded treatments were the highest producing in the interseeding trial. In 1971 and 1972 their production was less than the high N treatments. In 1973 and 1975-1978 their yields were not significantly different than the highest yielding fertilized treatments.

The application of 75 or 112 kg/ha N with or without P changed the mixed grass community to one composed mainly of single stocked cool season grasses. The shortgrass component of the community was affected differently by the fertilization than the interseeding treatments. On the interseeded plots, shortgrass production declined the first year due to destruction by the interseeder and slowly recovered on all but the alfalfa and smooth brome treatments. On the plots given yearly application of N the shortgrass production slowly declined during the 8-year trial. Perennial forb production was higher on plots receiving N fertilizer than on the interseeded plots. Annual forb production remained nearly the same on all treatments in both trials with the exception of the 56 kg/ha P treatment, which nearly tripled the production.

Key words: fertilization, interseeding, range improvement, range ecology, mixed grass prairie.

7-9-1

Effects of Climatic Zone, Topography, Land Utilization, and Soil Condition on the Nutrient Composition of the Natural Grass in Bali

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A survey based on climatic zone (zone B, C, D, E and F), topography (coast, hill and higher altitude), land utilization (rice field, dry land and plantation) and soil condition (moist and dry surface) was carried out during the wet (January to February 1979) and dry (August to September 1979) seasons in 15 Districts of eight Regencies in Bali. The objective was to study the quality of the natural grass commonly fed to livestock in the mixed farming system.

During the wet season, the crude protein content (on dry matter basis) of the natural grass varied from 7.38% (in climatic zone D on the dry soil) to 13.07% (in climatic zone E at higher altitude) and during the dry season the protein content varied from 3.64% (in climatic zone F on the dry soil) to 13.62% (in climatic zone C at higher altitude). The crude fibre content varied from 22.14% (in climatic zone B at higher altitude) to 29.89% (in climatic zone F on the moist soil) and 23.30% (in climatic zone B on the moist soil) to 30.52% (in climatic zone F on the dry soil) during the wet and dry seasons, respectively. The gross energy content varied from 3482 kcal/kg (in climatic zone B on the moist soil) to 4278 kcal/kg (in climatic zone F on the dry soil) during the wet season and during the dry season the value varied from 3637 kcal/kg (in climatic zone C on the moist soil) to 3992 kcal/kg (in climatic zone F on the coast).

The present data indicate a ranking order effect of climatic zone > topography > soil condition > land utilization on the nutrient composition of the natural grass. The crude protein content was affected the most whereas the gross energy content was affected the least by the above-mentioned parameters.

Key words : climatic zone, topography, land utilization, soil condition, nutrient, natural grass, seasons.

7-9-2 Effects of Water Stress on Herbage Quality

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Uncertainty exists about whether drought is detrimental to the nutritive quality of herbage.

This paper tries to resolve this uncertainty by examining the influence of soil moisture on some herbage quality characteristics. Unpublished data from my own work and a review of published literature are presented.

Field plots of three tropical grasses, green panic (*Panicum maximum* var. *trichoglume*), buffel grass (*Cenchrus ciliaris*) and spear grass (*Heteropogon contortus*) were subjected to periods of controlled drought and herbage from these plots compared with that from well-watered plots. Leaf and stem dry matter digestibility of water-stressed herbage was either similar to or higher than that of unstressed herbage. Sward digestibility in droughted plots was higher than the well-watered controls because of a decreased proportion of stem and a higher digestibility of both leaf and stem.

The review of the published literature indicates that low soil moisture rarely has an adverse effect on herbage quality. The available information leads to the conclusion that the animal liveweight gain should be better than usual under conditions of low soil moisture unless low pasture yield seriously restricts intake. Information from a grazing experiment in Australia supports this contention.

Key words: tropical grasses, herbage quality, digestibility, water stress, drought, animal performance.

7-9-3

4-Year Evaluation or 11 Forage Species at Anthesis

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Forage species need to be evaluated not only for dry matter (DM) production, but also for animal maintenance or weight gains per hectare of forage harvested. The DM yield and *in vitro* digestibility (dig.) were determined at anthesis on seven grass species, three ('Rambler', 'Drylander', 'Orenberg') alfalfa cultivars [*Medicago sativa* L. subsp. X *varia* (Martyn) Arc.] and 'Lutana' cicer milkvetch (*Astragalus cicer* L.) grown near Sidney, Montana during 1975, 1976, 1978, and 1979. In 1974, the forages were seeded in rows 50 cm apart and grown under dryland conditions. *In vitro* dig. was converted to estimated *in vivo* dig. with data from eight forage samples with known *in vivo* dig. The amount of beef weight gain per hectare that each forage would produce was estimated for a 300-kg steer. Intake was assumed to be proportional to dig. and was estimated by equations reported by Song and Dinkel. Dig. was converted into net energy and weight gains by equations reported by Lofgreen and Garrett.

Forages of 'Nordan' crested wheatgrass [*Agropyron desertorum* (Fisch.) Schult.] and of 'Luna' pubescent wheatgrass [*Agropyron intermedium* var. *trichophorum* (Link) Halac.] had the least dig. (<55%) the first year and also the following three years (<59%). Forage of cicer milkvetch, alfalfas and 'Sidney Sel.' reed canarygrass (*Phalaris arundinacea* L.) had the highest dig. the last three years (>65%).

Maintenance of the most animals (mature) per hectare of forage harvested depends upon the production of the most digestible DM as long as dig. is above 50%. Alfalfas produced the highest dig. DM the first year (2.2 mt/ha); while 'Prairieland' Altai wildrye (*Elymus angustus* Trin.) cicer milkvetch, and alfalfas did so during the following three years (1.5 mt/ha). Altai wildrye and 'Mayak' Russian wildrye (*Elymus junceus* Fisch.) produced the lowest dig. DM the first year (<0.3 mt/ha) while reed canarygrass and 'Regar' meadow bromegrass (*Bromus bielbersteinii* Roem. & Schult.) did so during the following three years (1.0 mt/ha).

It was estimated that cicer milkvetch and alfalfas when harvested at anthesis would produce the most weight gain when fed to a 300-kg steer all four years (>100 kg/ha); while during the last three years crested wheatgrass, pubescent wheatgrass, and 'Lodorm' green needlegrass (*Stipa viridula* Trin.) would produce the least weight gain (<50 kg/ha).

Orenberg alfalfa was generally lower in DM yield and dig. than rambler or drylander alfalfas, but this difference was generally not significant.

Key words: dry matter yield, digestibility, weight gains, crested wheatgrass, pubescent wheatgrass, meadow bromegrass, Russian wildrye, altai wildrye, reed canarygrass, green needlegrass, alfalfas, cicer milkvetch.

7-9-4

Environmental Influences on Forage Quality of Kleingrass

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Forage digestibility of sub-tropical grasses generally decreases from spring to summer in the Southwestern U.S. The mid-summer periods when forage digestibility is below the nutrient density requirements of many classes of livestock, is characterized by high temperatures and low rainfall. Discernment of the relationship between environmental factors and forage digestibility will facilitate development of management systems and breeding of forage genotypes to minimize seasonal reductions of digestibility during periods of high temperature and low rainfall.

The major objective of this research was to determine the relationship between specific environmental factors and forage quality of kleingrass (*Panicum coloratum* L.). Yield, *in vitro* digestible organic matter (IVDOM), percent leaf, and neutral sugar components of structural carbohydrates of leaves and stems were determined for field grown plants harvested at 2,4, and 8-week frequencies during a 24-week growing season. Correlation and regression analyses were used to quantify relationships between specific climatic variables and forage quality for the 1978 and 1979 growing seasons. The relationships of plant and soil water status to IVDOM and leaf anatomy were further investigated for potted plants grown in the glasshouse.

Under field conditions, IVDOM of leaf and stem was negatively correlated with temperature and day length and positively correlated with measures of moisture conditions (rainfall and percent soil moisture). Statistically significant multiple regression equations using environmental factors to explain IVDOM were obtained. However, the R-square values obtained and the specific environmenatal factors contributing significantly to the equations were not consistent among forage ages and years. Under glasshouse conditions, forage digestibility decreased tremendously as moisture stress increased. Cell wall thickness and proportions of conducting tissue in relation to parenchyma tissue increased markedly with moisture stress.

Leaf IVDOM was negatively correlated with arabinose and xylose concentrations and positively correlated with glucose concentration. Significant correlations were obtained between structural carbohydrate neutral sugar concentrations and environmental factors indicating that forage digestibility differences associated with environmental conditions during the growing season may be mediated, at least in part, through changes in structural carbohydrates. These structural carbohydrate changes are likely associated with secondary cell wall development.

Forage quality-environmental factor correlations indicate that forage digestibility decreased in response to high temperatures, moisture stress, and long days during the growth period. Although the relationship observed between temperature and digestibility has previously been reported for other grass species, the distinct reduction of forage digestibility observed with moisture stress of field and glasshouse grown plants has not been reported and provides new insight into the seasonal forage quality pattern.

Key words: kleingrass, *Panicum coloratum* L., forage quality, structural carbohydrates, moisture stress.

7-9-5 Efficiency of Micronutrient Fertilizers on Grasslands Irrigated with Clean Water and Sewage

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A number of biogeochemical regions in the Soviet Union are characterized by a deficiency of mobile forms of certain microelements in the soil; in particular, the non-chernozem zone of the European part of the country. Under conditions of intensive fodder production, especially when higher rates of fertilizers and irrigation are used, the problem of proper supply of microelements for grasses is of major practical significance.

Field trials were established on grassland seeded mostly with cereals and irrigated with clean (river) water or sewage (industrial and domestic), on soils which are typical for central non-chernozem regions. The effects of micronutrient fertilizers (kg/ha) -- Copper (Cu, 4-5), Zinc (Zn, 4-5), Boron (B,1), Molybdenum (Mo, 0.3-5), and Cobalt (Co, 0.3)-- on the grass yield and its quality were studied. The fertilizers were applied separately and in mixtures as topdressing to a complete fertilizer ($N_{180-300}P_{80-100}K_{120-150}$). In more complex agrozootechnical agronomic investigations, micronutrient fertilizers were applied to experimental grasslands to measure effects on fodder quality, cows' health and productivity and quality of milk and processed milk products.

On soddy-podzolic sandy loams all the investigated microelements increased yields with the greater increases resulting from Cu (15.8%), B (14.6%), and Zn (14.4%). The maximum increase in yield of dry mass (22.6%) resulted from the application of complete micronutrient fertilizers. On soddy-podzolic loamy soil, with average amounts of Cu, B and Mo, the yields were improved only by Zn (13.5%), and Co (14.9%). When the two elements were excluded from the complex of micronutrient fertilizers, the yield was lower. Grasses cultivated on peaty soil responded well (increase of more than 10%) to Mo, Zn, and Co fertilizers. Cu was effective in combination with Co, and B was effective in combination with all the other microelements. Gray forest soils first and foremost needed Zn and Mo. Cu and Co produced beneficial effects only when applied together, as well as in combination with Zn and Mo.

The micronutrient fertilizers in question increased the amount of corresponding microelements in grasses in almost every case, but they did not produce significant effects on the other qualitative features of fodder. Irrigation with sewage did not alter the response to micronutrients as it contained rather little of the deficient microelements. Micronutrient fertilizers reduced the concentration of nitrates in the grass and increased some amino acids. On grasslands micronutrient fertilizers somewhat increased milking productivity in cows and their reproductive ability, improved the biological value of milk both in vitamin level and as a medium for the development of indicative culture of microorganisms.

Key words: microelement fertilization, grass yield, grass quality, milk production, milk composition.

7-10-1 Forage Quantity and Quality Contributions from a Grass-Legume-Shrub Planting on a Semiarid Rangeland

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Poor grazing management and resource misuse have led to deterioration of vast expanses of the world's semiarid rangelands. Deterioration has proceeded to a point on many semiarid rangelands where revegetation offers the only acceptable alternative. Although combinations of grasses, forbs, and shrubs are desirable in the revegetation of these areas, past revegetation has mainly involved the establishment of monocultures of perennial grass. Our objectives were to determine the forage and protein yields of a grass-legume-shrub planting in a semiarid rangeland.

The study was conducted in central Utah on a rangeland receiving 32 cm of annual precipitation. Crested wheatgrass (Agropyron cristatum) was established alone and in combination with fourwing saltbush (Atriplex canescens), alfalfa (Medicago sativa), sicklepod milkvetch (Astragalus falcatus), and cicer milkvetch (Astragalus cicer). Transect segments were set up and all of the current year's above-ground production for each species was clipped, dried, weighed, and analyzed for total nitrogen. Three replicate transects were harvested for each legume treatment once during 1978 and three times in 1979.

Forage and protein yields were increased 2- to 4-fold when crested wheatgrass was grown in association with either fourwing saltbush or legumes compared to when crested wheatgrass was grown alone. Greatest yields were noted in transect segments where crested wheatgrass was growing with fourwing saltbush, followed by segments where crested wheatgrass was growing with the legumes. Of the legumes, alfalfa associations with crested wheatgrass yielded the largest amounts of forage and protein, followed by associations with sicklepod and cicer milkvetch, respectively. These enhanced yields in areas where crested wheatgrass was growing with other species were due not only to an increase in high quality forage provided by the additional species, but also to an increase in forage and protein yield in the crested wheatgrass component.

Revegetation of semiarid rangelands with combinations of crested wheatgrass, fourwing saltbush, and legumes (particularly alfalfa) will provide a more productive, higher quality forage resource than only crested wheatgrass. These combinations could extend the grazing season and provide a broader ecological base for increased ecosystem stability than a monoculture of crested wheatgrass.

Key words: crested wheatgrass, Agropyron cristatum, fourwing saltbush, Atriplex canescens, alfalfa, Medicago sativa, cicer milkvetch, Astragalus cicer, sicklepod milkvetch, Astragalus falcatus, forage yield, protein yield.

7-10-2

Age, Date of Cutting and Temperature as Factors Affecting Chemical Composition of Berseem (*Trifolium alexandrinum* L.)

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Chemical composition of berseem produced in winter and spring, under irrigation in Morocco, was investigated in a 4-year study. Berseem was planted at various dates and after harvesting the first cut, samples were taken from each regrowth at weekly intervals. Total plant, leaf and stem samples were analyzed for dry matter (DM), ash, crude protein (CP) and crude fiber (CF). A total of 172 samples of aerial regrowth were analyzed and used to calculate multiple regressions of chemical composition on age and date of cutting. Date of cutting was defined as number of days after August 1.

Regrowths remained vegetative from November to early May, when flowering occurred. Dry matter remained low (8 to 12%) during winter and spring and reached 20% only in June. Ash was always high (12 to 20%), while CF did not exceed 30%. Crude protein varied between 18 and 30%. At a given date of cutting, CF increased and ash decreased .19 and .06 percentage units per day of age, respectively. DM increased rapidly when plants grew old, while CP decreased while they were still young. At constant ages of cutting, regrowths showed a slight decrease in DM from November to the end of January and then increased until June. Ash decreased more rapidly with the advancing season from November to June than CP. Crude fiber increased dramatically during the same period. The effects of date of cutting appear to be a combination of effects of regrowth number, stage of maturity and temperature. When samples of the same regrowth number and stage of maturity were compared, there was considerable variation from year to year of samples of similar ages for leaf percentage and chemical composition. For CF, variation exceeded six percentage units.

Multiple linear regressions between morphological or chemical composition, age and average temperature showed that temperature partly explained these variations. Temperature decreased leaf percentage for both 1st and 2nd regrowths, but not for the 4th. It also increased DM percentage rapidly in the last regrowth. Partial regression coefficients between CF and average temperature were 1.38, 1.75 and .92 for 1st, 2nd and 4th regrowths, respectively, while those with ash and CP were always negative. Regressions are also presented for stems, but not for leaves which appear to have nearly constant CF content. Temperature appeared to increase CF of berseem by stimulating its maturity, but also by a specific action on the fiber content of stems.

Key words: berseem, *Trifolium alexandrinum* L., chemical composition, age, season, temperature.

7-10-3 Quantitative and Qualitative Evaluation of Irrigated Pasture for Goat Meat (Cabrito) Production in Northern Mexico

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This study was conducted during 1979 in the central part of Chihuahua in northern Mexico. The objective was to evaluate the vegetational and nutritional characteristics of three species forming the pasture.

The study area is established with L. perenne, F. arundinacea and A. elongatum in the proportion of 40, 40 and 20% respectively. The stocking rate fluctuated from 2500-3000 kg of meat/ha of native goat with the purpose of selling weanling "cabritos." The area is divided into four plots of 5 ha each; the basal cover was measured in each plot by five line transects randomly distributed, each 10 m long. Forage production was determined on 10 circular plots, 1 m^2 each.

The herbaceous cover dynamic showed this tendency: in January the average cover was 18%, in February increased to 23%, then decreased to 17.5% in May, probably due to high temperature, and in July increased to 32%, finishing in December at 28%. The basal cover for A. elongatum decreased from 4% to 0.5% from January to December as L. perenne and F. arundinacea increased from 13 to 19% and 2.5 to 9% respectively. L. perenne showed always more cover and biomass production. The total biomass in D.M./ha was 682 kg in January, increasing as the environmental temperature increased to reach 4784 kg/ha in August, then decreasing with cold temperatures to 1080 kg/ha in December. The chemical composition of the grasses of the pasture did not change significantly through the year, the average C.P. for L. perenne, F. arundinacea, and A. elongatum was 19.7, 18.66, and 19.0, respectively. The average E.E was 3.39, 2.72, and 3.96%, respectively, and the C.F showed values of 20.21, 22.69, and 22.0 for each species.

Some of the conclusions of this study were: (1) The dynamic of the biomass and vegetational cover through the year showed close relationship with the climate conditions and stocking rate. (2) The nutritional value of the pasture did not show significant variability through the year. This tendency was more significantly related to the irrigation and fertilization practices. The study revealed the basic characteristics for good management of pasture of this type, but further studies are required related to animal behavior in this pasture.

Key words: goat, qualitative, quantitative, Lolium perenne, Festuca arundinacea, Agropyron elongatum.

7-10-4

Fire Succession of Mountainous Meadow Vegetation in the South of Gansu

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The authors have made observation and study on the fire succession of three subtypes of meadow vegetation distributed in the mountain ranges of Gansu, with the purpose of evaluating the effect of fire on the productivity of this typ of vegetation. The results are as follows:

1. After burning, the production of forage grasses in fresh weight increased by 14.35% on an average, and the increasing rate of true meadow subtype reached the value of 18.77%. In various economical groups of herbage, species of sedge family (Cyperaceae) increase most remarkably after fire, the mean increasing rate of the three subtypes being 44.20%. Yet the true meadow subtype gained a value of 140%. The yield of species of grass family (Gramineae) dropped down by 18.18%, on average, after fire. The ruderal remained almost the same.

2. The effects of fire on various types of life-forms were quite different. Fire plays a role of stimulating growth of those plants with subterranean rhizomes such as Carex spp. and some grasses. But it results in suppression of growth of those tufted tall grasses with their renew buds above ground, such as Clinelymus nutans and Roegneria nutans, and is unfavourable to those close tufted short grasses such as Stipa aliena also. Dwarf shrubs Hippophae rhamnoides and Dasiphora fruticosa var. pumila are seriously hurt by fire.

3. In spring, the forage grasses of these meadows turn green 15 to 18 days earlier than those without burning, and period of utilization of these subtypes of natural pasture is prolonged.

4. This burning favours suppression or destruction of insect pests and diseases of pastures and livestocks.

Accompanying the above-mentioned advantages there are shortcomings of a small degree of decline in quality of forages and their palatability. Nevertheless, taking both sides into account, the advantage is apparently greater than the shortcoming. Therefore, the authors consider that burning is one of the useful measures in raising productivity of these pastures.

Key words: fire succession, meadow, pasture productivity, life-form.

7-11-1 A System Approach to Swedish Ley Production

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A simple simulation model (FOPRO-1) for estimating yield of leys from standard meteorological observations is described. The model is based on an S-shaped growth curve, which provides an envelope of potential production and also provides for phasic development and regrowth depression. Climatic and soil influences are accounted for by a Growth Index, which incorporates effects of temperature, radiation and soil moisture. Soil moisture is simulated with a water budget in which rainfall, evaporation, plant-available soil water and canopy cover are considered.

The parameters in the model are estimated in a minimization procedure by comparing measured with calculated growth using daily or weekly weather data. After parameter optimisation the model predicted final harvest with reasonable accuracy, but there was a consistent underestimate of early season growth, presumably due to mobilisation of carbohydrate from storage organs.

For validation of the model, observed ley yields from 49 parishes throughout Sweden from 1961-1978 were compared with model calculations. The comparison showed a correlation coefficient between observed and calculated yields of 0.9.

Deviations between observed and estimated yields formed a geographic pattern. North of latitude 59°N the model underestimated the first hay cut, while south of this line yields were overestimated. For the second cut the deviations were reversed, but the boundary line between northern overestimates and southern underestimates was approximately at 60°N. This geographical pattern suggests a gradient in assimilate storage in autumn and its mobilisation in the spring, with more storage and subsequent mobilization in northern regions with the longer and more severe winters, than in southern regions with the milder winters.

Key words: forage production, growth prediction model, crop-weather interactions.

7-11-2

Energy Flow and Conversion Efficiency in Grazing Grassland

2

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Recently, beef and milk have become more important as a protein source in Japan. Because of the demands for a stable supply, grassland developments were carried out in many districts. However, conservationists opposing this development strongly demand preservation of the natural environment.

To meet these demands, there is a need for clarifying the dynamics of materials and energy in grassland ecosystems. The purpose of this paper is to present the results of quantitative ecological investigations aimed at clarifying the pattern of energy flow through atmosphere, pasture plants and cattle in a grassland ecosystem and to present energy conversion efficiencies through the ecosystem that lead to practical consideration for management of grassland, and to maximize the animal production while protecting the environment.

Measurable energy storage on grassland ecosystems was examined for five years at the Fujinita site under the same rotation program with two grazing intensities.

Daily global solar radiation and photosynthetic active radiation was measured as the energy sources in the ecosystem. Primary production by pasture plants and grazed amount by cattle were estimated by the biomass differences inside and outside of protection cages. For the estimation of energy produced or stored by plants or cattle, calorific values were examined for dominating plant species at the Fujinita site. Seasonal changes of digestibility were investigated to ascertain the digested energy by cattle. For the evaluation of stored energy in cattle, ARC feeding standards were adopted according with the increment of body weight.

As the results of determination of energy accumulation, the energy conversion efficiency through the system was calculated. Out of 9.74×10^5 kcal/m²/yr of global solar radiation, the rates of 6.10×10^{-3} and 5.78×10^{-3} were utilized in primary production for light (L) and heavy (H) grazing plots, respectively. Intensive grazing in plot H caused much utilization of photosynthate and also higher digestibility values in pasture plants (0.600 and 0.695 for plot H and, 0.523 and 0.657 for plot L). Overall efficiencies beginning with solar radiation and terminating as stored energy in cattle were 7.43×10^{-5} and 9.61×10^{-5} for plot L and plot H, respectively.

Key words: grassland ecosystem, energy flow, cattle, global solar radiation, pasture plants, calorific values, digestibility.

7-11-3

Simple Computer Simulation Models for Forage Management Applications

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Dynamic computer simulation models of forage growth can be useful in interpreting physical and biological limitations on production and in designing management systems for testing in the field. The explanatory detail of such models makes them both more reliable and more expensive to use than simple empirical formulations. Simple simulation models reduce the expense. They can also serve as reference points for designing, evaluating, or selecting more complex versions and thus provide a more rational basis for using models in grassland research and management.

Our objectives were to develop and to test a simple dynamic simulation model of alfalfa (Medicago sativa L.) production using a combination of explanatory and empirical functions. Yield and forage quality in terms of digestibility and crude protein concentrations were predicted, and model testing was used to establish a reference point for evaluating more complex alfalfa models, several of which are available. The rationale of model development was to include the primary factors that cause variation in alfalfa yield. Genetic yield potential, moisture supply, temperature effects, and cutting management were selected as the most important variables. Cutting management was assumed to operate through its effect on root reserves in the control of regrowth potential and winter survival. Appropriate functional relationships were taken from other models or derived from data in the literature. Forage quality prediction was based on an empirical relationship with time or growing degree days as the independent variable. The model was named ALSIM 1 (LEVEL 0).

The LEVEL 0 model simulated expected patterns of dry matter accumulation and soil moisture supply for the northeastern U.S.A. It also indicated that temperature stress is an important element of yield determination in alfalfa, and that the phenological development of at least some cultivars must depend on daylength as well as temperature. Critical tests of LEVEL 0 involved simulations of 60 observations from three harvest schedules over two years at three locations with differing supplies of soil moisture. The linear regression of observed yields on predicted yields rendered the equation $Y = 0.844 + 0.726X$ with $r^2 = 0.62$ and $S.E._y = 0.870$ metric tons/ha. There is considerable room for statistical improvement, but LEVEL 0 will be adequate for preliminary study of harvesting options. Corresponding analyses for digestibility and crude protein concentration rendered $r^2 = 0.25$ and 0.13, respectively, with $S.E._y$ on the order of 3 to 5 percentage units. An empirical, time-based quality model is not adequate.

Key words: alfalfa, lucerne, Medicago sativa L., soil water budget, temperature effects, genetic potential, forage quality prediction, model testing.

7-11-4 Can Simple Models Predict Rangeland Yields?

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Many simple regression models have been built to estimate annual plant production from climate. Although most apply within only a limited locale, some claim generality. This study shows that a time-series version of such a model can estimate aboveground rangeland production accurately at a variety of sites.

I tested six published models, all algebraic equations relating yield to climate. Using data from 38 rangeland sites in North America, Asia, Africa, Australia, and Europe, I calculated estimates of annual yield for each model and determined the influence of climate variables, site factors, and past-year yields and climate on model accuracy. For parametric analyses, data were taken as logarithms.

The models alone accounted for 55% to 70% of the variation in yields ($P<.0001$). In ascending order of success were: two models based solely on precipitation; a model based on the ratio of precipitation to potential evapotranspiration and on growing season temperature and length; two models based on actual evapotranspiration; and a step-function model taking precipitation and temperature as limiting factors.

Soil texture and method of sampling yield did not account for significant additional variation ($P<.05$); vegetation type did, for the precipitation-only models, and interaction between these factors did for the model incorporating precipitation/potential evapotranspiration ratio.

Absolute error as a percent of yield was associated negatively with actual evapotranspiration for one precipitation model and with no variable for the other (Spearman rank correlations, $P<.05$ throughout). For one actual evapotranspiration model, absolute percent error was associated negatively with latitude, growing season temperature, product of elevation and latitude, and Thornthwaite moisture index, and positively with temperature, potential evapotranspiration, and growing season length. For the remaining three models, absolute percent error was associated negatively with actual evapotranspiration, actual/potential evapotranspiration ratio, precipitation/potential evapotranspiration ratio, moisture index, and precipitation.

Lagged (past-year) values affected model performance most. Therefore I rebuilt several models as rangeland time-series models, by incorporating past yield and regressing rangeland data, and tested them on new data. The rebuilt step-function model (precipitation and temperature as limiting factors) made predictions accounting for 96% of the variation in yield at new sites; a rebuilt actual evapotranspiration model accounted for 92%, or 85% using estimated past yield ($P<.0005$ for all tests).

The results show that if past-year yield is included in a model built on rangeland data, either a step-function model taking precipitation and temperature as limiting factors or a model based on actual evapotranspiration can account for much of the variation in rangeland yield, despite site and climate differences. Lagged yield may best integrate factors determining site potential, while current effective moisture may best differentiate one year's yield from another.

Key words: model, rangeland yield, plant production, climate, time series, evapotranspiration, precipitation.

7-11-5 Spatial Simulation Modelling as a Tool in Multiple-Use Management of Renewable Resource Systems

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A conceptual model was developed using a modified state variable approach, which involved the recognition and suitable description of specific objects, processes and situations considered relevant to the simulation of ecosystem dynamics. Six primary ecosystem subsystems were selected: terrestrial abiotic, floral and faunal, aquatic abiotic and biotic, and topographic land use. These subsystems are embodied by a geographic structure defined as an ecological response unit (ERU). Subsystem characteristics of an ERU are considered homogenous while between ERUs the characteristics may differ greatly. A set of ERUs may be arranged into any mosaic pattern. This structure affords a unique response behaviour to both the individual ERUs and the mosaic pattern. Discrete management events, such as controlled burning or livestock stocking, and continuous events, such as shale oil mining, may be scheduled for a complex of ERUs. The model operates "mechanistically", so that the results are tractable and provide a framework for interpretation and discussion among resource managers.

A computer based simulation model of the conceptual model, named An Ecosystem Simulation of Perturbations (AESOP), has been developed to provide resource managers with a methodology for analyzing the future consequences of multiple-use management scenarios. The computer model provides pseudo quantitative ecosystem responses as a consequence of various management strategies. AESOP allows a user to specify many types of scenarios involving both ecosystem characteristics and management practices, which may vary in location, timing and magnitude.

AESOP was programmed in the general purpose computer language PASCAL because of its superior data typing and program structuring capabilities, which allow model flexibility not possible with most models reported in the ecological literature. AESOP closely imitates the conceptual model through data structuring techniques and derived mathematical functions representing ecosystem relationships. The block structure of the computer program provides ease in user understanding and evaluation, and change or interchange of simulation procedures.

AESOP generates pseudo time-series data of the components and processes of the ERUs and indices of subsystem conditions. A separate anlysis program summarizes the voluminous output into statistical tables and graphs.

The model is presently being tested by evaluating ecosystem response to multiple-use resource management of the sagebrush-grassland in northwestern Colorado. This region is unique in its richness of energy producing resources, its abundance of wild herbivores and its livestock and agricultural practices.

Through the analysis of the results from various management policy scenario simulations, a pseudo "hindsight" is available to the resource manager at the time of decision making.

Keys words: simulation, spatial, model, AESOP, data structure.

8-1-1 Effect of Experimental Methods on the Results of Voluntary Intake Experiments with Grass Cultivars

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The amount of forage eaten by farm animals is an important plant character. It is influenced by a number of internal and external factors. Experimental results on the subject reported in the literature are often controversial. This may be partially due to the methods of evaluation employed. We studied if and to what extent different experimental procedures would influence the results of intake experiments in grass cultivars.

Voluntary intake of four cultivars of Lolium perenne differing in ploidy level and earliness when fed to sheep ad libitum was assessed using five different procedures viz. fresh: dried forage; grazing: barn feeding; free choice: no choice between cultivars; feeding at different stages of growth: feeding at same stage of growth.

Highly significant differences between cultivars were found when offered fresh for free choice in situ (grazing) as well as in the barn at same dates. Late cultivars were preferred to early ones, and tetraploids to diploids. Essentially the same results were obtained when hay of the flowering stage was offered for free choice. When hay of the cultivars was fed as single feeds, differences between cultivars varied with stages of growth. They were larger at earlier than at later stages, and sometimes interactions occurred. Hay intake decreased significantly with advancing stages of growth. The effect of stages of growth at harvesting time of the feeds was much larger than that of the cultivars.

Genetic differences with respect to voluntary intake between grass cultivars suggest the possibility of genetic improvement by plant breeding measures. The procedures for assessment of intake should be chosen according to the intended use of the forage.

Key words: intake, grass cultivars, Lolium perenne L., evaluation methods, sheep.

8-1-2

Evaluation of *Sasa senanensis* on Hokkaido Island, Japan

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In Hokkaido, there are three types of Sasa genus: large-sized Sasa (*Sasa kurilensis*) is distributed about 700,000 hectare and the green weight is estimated 44 million tons; middle-sized Sasa (*Sasa sinanensis*) is 1,690,000 hectare and 42 million tons; and small-sized Sasa (*Sasa nipponica*) is 1,610,000 hectare and 15 million tons.

Following studies have been undertaken to evaluate the grazing value of Sasa on the experimental forest located in Sapporo, Hokkaido: (1) observation of charactaristics and estimation of standing crops of Sasa; (2) studies on the vegetational changes of Sasa under the effects of animal grazing: and (3) remote sensing of Sasa grasslands and estimation of grazing capacity.

Sasa increases by shoot sprouting and the span of life is about six years. On the average, three leaves develop in a year and the life of them is about three years.

After grazing, the vegetational change of Sasa was observed as follows: (1) plant height, density and standing crops were severly decreased; (2) grazing damage was heavy in the spring-summer grazing plots and slight in the autumn plots; and (3) Sasa recovered from grazing damage within three years.

Inspite of poor digestibility, Sasa is the most important forage in Hokkaido, because it has strong stems and is able to stand under deep snow.

Remote sensing is very effective to estimate the distribution of Sasa. Sasa is easily classified, using the photographs of late autumn.

Using multispectral scanner data, we observed the reflectance of Sasa leaves and found that there is a negative correlation between red band and near infrared band. We could reveal the distribution of Sasa by the subtraction of red band reflection from infrared one.

Animals graze irregularly on the Sasa grasslands, the difference of grazing rate being caused by topographic conditions. We combined the Sasa vegetation with the map of topographical conditions and estimated the grazing capacity by grid sqare mesh map method.

Key words: *Sasa senanensis* Rehd., bamboo grass, cattle, remote sensing grazing capacity.

8-1-3 Nutrient Composition of Interplanted Soybean and Grain Sorghum Plant Parts with Advancing Stages of Maturity

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Both stage-of-maturity and ratio of plants in a soybean-grain sorghum mixture influence the mineral composition, the total protein and the solubility of that protein; however, composition data on these plants concerning the degree of differences or the range in values are limited. Thus, interplanted soybean (100 to 135 kg/ha and grain sorghum (17 to 23 kg/ha) were initially harvested at 9 wk post-planting in the vegetative (veg) stage. Over the next 9 wk, four additional samples were harvested to determine the ratio and chemical composition of veg and seed parts for each plant at an advancing stage-of-maturity. Both soybean and grain sorghum plants have high-energy potentials as feedstuffs for cattle. However, the two plants differ in protein profile or protein solubility and in mineral composition. Initial veg dry matter yield was 6,300 kg/ha at 9 wk from year 1. Dry matter yield increased to 15,000 kg/ha with 52% veg. Chemical compositions at day 123 for the veg parts were 56% estimated TDN, 46% ADF, 9% protein. NDF was 74% for grain sorghum amd 57% for soybean with the difference contributed by hemicellulose. For the grain parts, TDN was 75%; NDF was 40% for grain sorghum and 28% for soybean with the difference contributed by hemicellulose; ADF was 18% and protein was 9% for grain sorghum and 29% for soybean. Sodium chloride insoluble protein values were 79% in grain sorghum head, 67% in grain sorghum veg and 58% in both parts of soybean. Thus, protein quality for ruminant animal utilization favored the grain sorghum. Grain sorghum mineral levels were as expected for calcium, phosphorus, potassium and zinc but lower or deficient for magnesium, sulfur, copper and manganese. In general, the grain and veg parts were not greatly different within forage, but values for the following minerals were uniformly lower for grain sorghum. Values for grain sorghum and soybean were 0.11 and 0.28% magnesium, 0.09 and 0.22% sulfur, 3 and 10 ppm copper, 11 and 24 ppm manganese and 14 and 24 ppm zinc, respectively. Both stage-of-maturity and ratio of plants and plant parts will be discussed; and, these data make strong suggestion for nutrient supplementation to achieve nutrient balance in the ruminant diet. (Supported in part by A. O. Smith Harvestore Products, Inc.)

Key words: soybean plant, grain sorghum, protein quality in ruminant diets, minerals

8-1-4

The Concept of Persistence

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The two most important characters used for the assessment of grass varieties in England and Wales are dry-matter yield and persistence. Persistence can be defined as the ability of a variety to retain its ground cover over time. It is assessed by measuring changes in ground cover over time. It is recorded at a fixed time of year (autumn) using a combination of eye assessment and point quadrat records. Results show that eye assessments of ground cover are well correlated with the objective measurement.

The effect of stress factors such as frost, drought, pests and diseases on ground cover should be considered separately from true persistence. In the UK serious stress problems are the exception rather than the rule. The relative rate of change in ground cover will depend on the management applied and the ground cover relationships of 2 or more varieties may differ with widely different managements. This paper reports the results of routine trials conducted by the National Institute of Agricultural Botany (NIAB) in England and Wales in 1975,76 and 77 to compare 60 varieties (tetraploid and diploid) of ryegrass (Lolium spp), and presents an analysis of the relationship between ground cover and yield.

Ground cover is a goodmeasure of the dry-matter yield present above ground level at the time of measurement. However, if the yield is assessed by cutting at a height of 3cm, prostrate varieties may have good ground cover but low yield and vice-versa.

In NIAB trials ground cover in the autumn of the 2nd harvest year was well correlated with 2nd harvest year yield in all 3 years (r = 0.93 xxx, 0.94xxx and 0.88xxx) for diploid and tetraploid varieties of Italian ryegrass (Lolium multiflorum). For tetraploid varieties of perennial ryegrass (Lolium perenne) the correlation was very good (r= 0.98xxx, 0.96xxx and 0.96xxx) but for diploid varieties the correlation was less good (r = 0.66xxx, 0.75xxx and 0.87xxx). The relatively low correlations between yield and ground cover found in diploid perennial ryegrass may be partly due to the wide range of growth habit in this group of varieties.

Varieties tend to have characteristic yield: ground cover ratios, dependent mainly on growth habit. This ratio is similar for both 1st and 2nd harvest years and makes it possible to distinguish low yielding prostrate varieties from high yielding erect varieties.

Variety	Ratio of Yield : Ground cover Harvest Year 1st	2nd	Single spaced plants height : width
Aberystwyth S24	1.87	1.59	0.91
Cropper	1.71	1.50	0.70
Barlenna	1.62	1.38	0.57

In the autumn of the first harvest year, differences between perennial ryegrass varieties in ground cover are usually small but these differences increase in subsequent years. The rate of change is a varietal characteristic. Because yields are well correlated with ground cover, varieties which show the steepest decline in ground cover usually show the steepest decline in yield.

persistence, ground cover, yield, Lolium, growth habit, varieties.

Key words: persistence, ground cover, yield, Lolium, growth habit, varieties.

8-1-5 Yield and Forage Quality of *Panicum virgatum*

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In the temperate areas of the United States, high temperatures and low soil moisture in summer limit the production of cool-season grasses and, consequently, the size of most beef cow-calf herds. Warm-season grasses are most productive in midsummer and may serve as a supplement to cool-season grasses for grazing and hay. Switchgrass (*Panicum virgatum* L.), a warm-season species native to the Great Plains, USA, was grown on soils low in available phosphorus at two locations in Pennsylvania to determine changes in forage dry matter yields, leaf (leaf blade):stem (sheath + stem) ratios, and quality of leaf and stem fractions associated with increased maturation. Forage was harvested at 10-day intervals at both locations beginning at the 3- or 4-leaf stage in late June and continuing until seed maturity in early August.

Forage yield at early head emergence averaged 4.72 metric tons/ha with no nitrogen fertilizer. Yield variability between locations and years was apparently due to previous stand management. Leaf:stem ratios declined as plants matured and in early August, stems accounted for 63% of the total dry matter yield. Leaf and stem forage quality estimates at early head emergence, respectively were: in vitro dry matter disappearance (IVDMD), 58.8, 47.2%; crude protein (CP), 8.5, 3.8%; neutral detergent fiber (NDF), 67.1 77.7%; and lignin, 4.7, 8.3%. In concurrent feeding trials conducted using sheep, IVDMD underestimated in vivo digestibility by 17 percentage points.

Percent IVDMD and CP generally decreased with leaf and stem maturation. The decline was greatest at the early harvests and less pronounced in leaves than in stems. In contrast, percent NDF and lignin generally increased with advancing growth stage, and changes were most rapid for stems at earlier harvests.

In conclusion, switchgrass can produce good yields of medium quality forage at low soil fertility levels during late June, July, and August when production of temperate grasses is inadequate. Grazing switchgrass at more mature growth stages would not only provide forage of adequate nutritional value for mature brood cows and stocker cattle but would also increase pasture carrying capacity. In a hay program, harvesting at early head emergence would provide the best alternative when considering yield, quality, and persistence factors.

Key words: switchgrass, *Panicum virgatum* L., warm-season grass, forage quality.

8-2-1

Use of Principal Component Analysis in Summarizing Nutritive and Analytical Characteristics of Forages

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Principal component analysis and other multivariate analyses have not been used extensively to analyse forage data. Our objective was the synthesis and summary of 98 digestion trials on forages using a principal component analysis.

The 10 variables studied in all trials were: dry matter (DM), crude protein (CP), digestible protein (DP), crude fiber (CF), ether extract (EE), nitrogen-free extract (NFE), ash (A), gross energy (GE), TDN and digestible energy (DE). Acid detergent fiber (ADF), acid detergent lignin (ADL) and cellulose (C) were summarized, in addition, for some forages.

When data on 13 variables in 24 hays were summarized, the first 2 principal components accounted for 62.9% of the within group variance. DE, TDN, CP, DP, EE and A were positively correlated with the first principal component (PC1). ADF, CF, ADL and C were negatively correlated to PC1. CP, DP, and ADL were positively correlated and NFE negatively correlated to the second principal component (PC2). A graphic code was used to classify hays made from grasses and legumes and from warm season and cool season plants. When plotted according to principal components 1 and 2, a clustering of data separating grass hays from legume hays and hays from cool season and warm season plants was observed. In data on 10 variables from 18 corn silages (Zea Maize), two principal components accounted for 77.3% of within group variance. In an analysis involving 10 variables of 34 sorghum (Sorghum vulgare saccharatum), PC1 and PC2 accounted for 59.8% of the within group variation. The first two principal components accounted for 75.4% of within group variance in 11 silages made from cereal crops.

Pooled data including 10 variables for 29 hays revealed that PC1 and PC2 accounted for 64.3% of within group variance. Likewise in pooled data on 69 silages, including 6 silages not stated previously, the two principal components accounted for 58.3% of the within group variance.

Principal component analysis permitted optimum summarization and clustering of desired information. It also permitted graphical presentation of variates according to the two principal components for easy diagnosis and evaluation. One may also identify latent clustering factors in the population.

Key words: principal component analysis, silage, hay, data bank, cattle.

8-2-2 Methodology for Determining Pasture and Animal Response Differences in Unbalanced Experiments with Intercorrelations among Treatments

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Conventional statistical analyses require balanced data sets. Unbalanced data can be analyzed using regression procedures, but excessive adjustments may occur for some treatment means. The objective of this paper is to evaluate an analysis of grazing trial data using generalized least squares. The data was obtained from a 6-year study involving 12 treatments with not all treatments appearing in all years. The analyses involved estimating variance components due to years, fields and random error and then using these to obtain adjusted treatment means. Variance component estimates for the complete data set were similar to estimates from two balanced subsets of the data. For the most part, adjusted treatment means for cow and calf daily gain, gain/ha and TDN/ha were similar to simple treatment means. Large differences that occurred had rational explanations. The statistical procedure used offers considerable promise when analyzing data from unbalanced experiments involving both fixed and random effects and large random disturbances. Further experience with this sort of analysis using both real and simulated data is needed.

Key words: variance components, adjusted means, cow, calves, grazing.

8-2-3 A Model of a Spatial Pattern of Grazing Cattle

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A spatial pattern of grazing cattle is important for effective management of a grazing field and the behavioral controls of the animals. The following are discussed here: (1) spatial pattern of grazing cattle; (2) changes in spatial pattern by behavior, such as rest, grazing, movement; (3) the equilibrium distance between individuals in a population.

The length of a cattle troop, i.e., the distance between the extreme left and extreme right individuals, was recorded every 5 minutes in a grazing field. It was found from the observations that there are 3 states in the spatial pattern: S_1 state, wherein individuals gather together in a small area and do not move for a while; S_2 state, where the troop spreads out but soon dwindles repeatedly; and S_3 state, in which the troop is separated into 2 or more subgroups.

Let the length of a cattle troop be r and the change during time length Δt be Δr. Then we have $\Delta r/\Delta t=f(r)+\epsilon$, where f(r) is a function of length r and ϵ is the factor of random movement which follows a normal distribution, $N(0,\sigma^2)$. Here, for simplicity, we assume f(r)= a-br, where a and b are constants. The 3 states of spatial pattern are as in the table, which also includes the estimated values of constants. The equilibria of troop length were 27.21 and 48.56 m in S_1 and S_2, respectively.

A biological population has random, aggregated or regular spatial pattern. An index to determine the spatial pattern of a cattle troop is proposed. Let the length of the longest periphery of a grazing field be s and the length of a troop be r again. Then the index is defined by $I=(n+1)r/(n-1)/s$, where n denotes the troop size in number. The spatial pattern can be determined by the following criteria: (1) an aggregated pattern, if $0<I<1$; (2) a random pattern, if I=1, and (3) a regular or repulsive pattern, if $(n+1)/(N-1)>I>1$. This index can be statistically tested against the null hypothesis: random pattern. It is concluded by the use of this index that (1) S_1 has almost the aggregated pattern, (2) S_2 is not significant against the random pattern and (3) S_3 coincides with the regular pattern. States S_1, S_2, and S_3 may coincide with behaviors of rest, grazing or movement, and repulsion between individuals, respectively.

Table. Three states of spatial pattern and the estimated values of constants.

State i	σ^2	$f(r)=a_i-b_i r$	Estimated σ_i^2	a_i	b_i
S_1	σ_1^2	a_1, $b_1>0$ for $f(r)>0$ $a_1=b_1=0$ for $f(r)\not>0$	86.5	30.2	1.15
S_2	σ_2^2	a_2, $b_2>0$ for all f(r)	194.4	74.0	1.52
S_3	σ_3^2	a_3, $b_3>0$ for $f(r)>0$ $a_3=b_3=0$ for $f(r)>0$	86.0	104.6	1.48
			(measured in meter)		

Key words: spatial pattern, cattle.

8-2-4 Initiative Research on the Calculation of Grassland Types by Exponential Method

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According to Professor Ren Jizhou's theory of classification of grassland in synthetic order, several basic points have been brought up. A distributive function of the exponent of grassland types has been postulated, as follows:

$$Z_i(\rho_i) = e^{-\lambda_i \rho_i}$$

According to the basic point $\sum_{i=1}^{48} Z_i(\rho_i) = 1$ a group of values of " λ_i " has been approximated and methods for calculating " ρ_i " have also been formulated, as follows:

$$\rho_i - \Sigma Q = \frac{|\Sigma Q - \Sigma Q_i|}{2000\ 2in\alpha_i} \quad \text{------- (when K is definite)}$$

$$\rho_i - K = \frac{2|K - K_i|}{C_0 \cdot 2 \cdot \alpha_i} \quad \text{------- (when } \Sigma Q \text{ is definite)}$$

In order to correct some errors, a group of revising function $f_i(\rho_i)$ has been adopted correspondingly.

Through calculation, answers to the numerical relations of transition among different grassland types, to the typological relations of grassland cultivation and to the possibility of forecasting the successful introduction and growing of zoological components and botanical varieties are given.

Key words: exponential method, classification of grasslands, grassland types.

8-3-1 Rate and Extent of Fermentation and Potentially Digestible Fractions of Various Roughages

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To determine in vitro digestion characteristics such as rate of fermentation and amounts of potentially digestible dry matter(PDDM), cell wall constituents(PDCWC), acid detergent fiber(PDADF) and cellulose(PDcellulose), six roughages were selected including rice straw, barley straw, corn cob, corn stover, orchardgrass and alfalfa. Roughages were ground through a 1.00 mm screen in a Wiley mill. Four replication samples were incubated for 0, 6, 12, 24, 36, 48, 72 and 144 hours and PDDM, PDCWC, PDADF and PDcellulose were determined by difference from indigestible residues remaining after 144 hours in vitro incubation. Rate constant for fermentation(K) was determined as the slope of regression of log natural residues upon incubation times from 0 to 72 hours, and fermentation time was estimated by 1/K.

Potentially digestible fractions were ranged from 54%(rice straw) to 80%(corn cob) for dry matter, 37%(alfalfa) to 73%(corn cob) for CWC, 42%(alfalfa) to 59%(corn cob) for ADF and 52%(rice straw) to 87%(orchardgrass) for cellulose. Fermentation rate constant of dry matter were ranged from 0.00661 hr^{-1}(alfala) to 0.01634 hr^{-1} (corn cob) and rate constant of PDDM was ranged from 0.02928 hr^{-1} (rice straw) to 0.04317 hr^{-1}(alfalfa). Fermentation rate constants of CWC and PDCWC were ranged from 0.00698 hr^{-1}(alfalfa) to 0.01444 hr^{-1}(corn cob) and 0.02505 hr^{-1}(corn stover) to 0.04436 hr^{-1}(alfalfa). Rate constants of ADF and PDADF were ranged from 0.00566 hr^{-1}(corn stover) to 0.01183 hr^{-1}(corn cob) and 0.01797 hr^{-1}(corn stover) to 0.04542 hr^{-1}(corn cob). Rate constants of cellulose and PDcellulose were ranged from 0.00955 hr^{-1}(rice straw) to 0.02156 hr^{-1}(corn cob) and 0.03529 hr^{-1}(rice straw) to 0.05028 hr^{-1}(alfalfa), respectively.

Corn cob had the highest amounts of potentially digestible fractions and also had the highest fermentation rate constant. Both rice straw and barley straw had the lowest levels of potentially digestible fractions as well as the smallest fermentation rate constants, but barley straw had higher levels for both potentially digestible fractions and rate constants than rice straw. Alfalfa had low amounts of potentially digestible fractions and small rate constants of each fractions but had very larger rate constants of potentially digestible fractions. Orchardgrass and corn stover had intermediate amounts of potentially digestible fractions, and corn stover had generally small fermentation rate constants but orchardgrass had large rate constants.

Key words: fermentation rate constant, fermentation time, potentially digestible fraction.

8-3-2 Bulk Volume: A Parameter for Measuring Forage Quality and Its Influence on Voluntary Intake

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This experiment was conducted to evaluate bulk volume (ml/gm meal) as a method to estimate the quality of grasses and to determine whether feed volume limits intake. Samples of two grasses, Lolium perenne and Festuca arundinacea, were collected at different stages of growth. The voluntary intake by dairy cattle of the grasses had been measured previously. The volumes of the samples and the volumes of the cell wall residues after 0, 6, 12, 24 and 48 hours in vitro digestion were measured. These volumes were incorporated in a fill model for the rumen, as described by Mertens. This model calculates the cumulative fill of the rumen from rate of passage, rate of digestion, digestibility, NDF: cell-soluble ratio and time between meals. The model was used to explain the variation in intake.

The original volumes of the grasses gave low correlation coefficients with the different cell wall fractions: NDF (0.28), ADF (0.18), hemicellulose (-0.14), cellulose (-0.04) and lignin (0.29). However, the volume of the initial cell walls was highly correlated with the amount of the cell wall components in the original sample: NDF (-0.91), ADF (-0.53), hemicellulose (-0.96), cellulose (-0.50) and lignin (-0.99). During digestion the bulk volume of the cell residues increased per gram residue, but the absolute volume decreased.

Table 1. Correlation coefficients between physical-chemical characteristics and quality parameters.

Physical-chemical characteristics	Quality parameters		
	Rate of digestion	Intake ($kg/BW^{0.75}$)	Digestibility
Volume grass	0.24	0.60	-0.58
Volume initial NDF	-0.67	0.56	0.83
Lignin (% DMB)	-0.65	-0.61	-0.80
NDF (% DMB)	0.68	-0.50	-0.64
ADF (% DMB)	0.47	-0.44	-0.37

The cumulative fill from the model when calculated before a meal starts gave a correlation coefficient with intake of -0.82. However, when calculated after a meal was finished, a correlation coefficient of -0.72 was found. Adding the volume to the model showed smaller correlation coefficients of -0.50 (before a meal) and -0.23 (after a meal).

This experiment showed that volume of rumen fill explains less of the variation than weight of rumen fill and that the cumulative fill, as a result of intake 24 hrs prior to a meal, had more influence on intake than the fill caused by consumption 0-240 hrs before a meal.

Bulk volume of the NDF fraction in a feed gives the best explanation for differences in digestibility and rate of digestion. The higher the volume, the faster the rate and the greater the extent of digestion.

Key words: bulk volume, forage evaluation, voluntary intake, digestibility.

8-3-3 Using a Dynamic Model of Fiber digestion and Passage to Evaluate Forage Quality

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Assessing forage quality depends upon not only the characteristics of the plant and animal, but also the dynamic interaction of the forage, rumen microorganisms and animal. Although static variables, such as composition or 48 hr *in vitro* fermentation, are important for characterizing feeds and predicting *in vivo* responses under standardized conditions, they provide limited information that can be used to assess forage quality in dynamic situations. In order to predict performance at points other than 48 hours of fermentation, static variables require different equations for each situation. However, dynamic properties such as rates of digestion and passage can be used to predict digestion for many situations when used in an appropriate mathematical model. Our objectives are to describe a dynamic model of fiber digestion and passage in the ruminant and to illustrate its use in assessing forage quality.

In the model, neutral detergent fiber is divided into three fractions: fast-digesting (>.02/hr), slow-digesting (<.02/hr) and indigestible. While the indigestible fraction can escape the digestive tract by passage only, the digestible fractions can disappear by both digestion and passage. Forage particles enter the rumen into large, medium or small particle size pools. As particle size is reduced, particles move from large to medium and medium to small pools. Escape from the rumen can occur only from the small and the medium particle size pools. All rates of passage and digestion are assumed to be first-order. The model requires twenty differential equations and has been implemented on the computer using both CSMP and CASP IV simulation languages.

The model can be used not only to predict forage quality under varying situations of plant and animal characteristics, but also to measure the relative importance of various factors in determining forage quality in terms of animal performance. By varying the digestion rate and indigestible fraction in the model, it is possible to obtain an estimate of their relative importance for digestion and intake. Of these two, the dynamic model predicts that the indigestible fraction has the greater influence on both digestibility and intake. Thus, if genetic variation exists, it would be more productive to select plants within a species with smaller indigestible fractions rather than faster digestion rates. Other simulations indicate that rate of passage is one of the more important variables influencing forage intake and digestibility.

The dynamic model adds a new dimension for assessing forage quality because it provides flexibility in determining the effects of changes in both the plant and animal on forage utilization. With accurate kinetic data, it provides a valuable tool for discovering the attributes of forage composition, morphology and physical structure which influence fiber utilization by ruminants.

Key words: digestion model, ruminant, forage quality, digestibility intake, passage, forage.

8-3-4 Relationship of Forage Evaluation Techniques to the Intake and Digestibility of Tropical Grasses

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The objectives of this study were to: (1) evaluate the quality of ten cultivars of tropical grasses cut at four stages of regrowth; (2) determine the relationship of forage chemical composition and *in vitro* rates of digestion to forage quality; (3) determine if use of a synthesized estimate of the rumen passage rate constant would improve predictions of digestibility.

Seventy-six grass hays, representing one cultivar of *Cynodon dactylon*, two cultivars of *Digitaria decumbens*, four experimental lines of *Digitaria* spp. and three cultivars of *Paspalum notatum* harvested at 2, 4, 6 and 8 weeks of regrowth, were fed *ad libitum* to wethers in a digestibility and intake trial. Organic matter digestibility (OMD) varied from 54.1 to 72.3 percent and organic matter intake (OMI) varied from 17.3 to 27.4 g/kg. Correlation between OMI and OMD was .47, which was not improved when considered within genera or within cultivars. Animal variation in OMI and ash-free neutral detergent fiber intake (NDFI) was best removed by powers of body weight of .92 and .93, respectively.

Hays were analyzed for crude protein, crude fiber, ash-free neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose, permanganate lignin, silica, *in vitro* organic matter digestibility (IVOMD) and *in vitro* NDF digestibility (IVNDFD). Lignin was the chemical component most highly related to OMD (r=.72). NDF was better than ADF as a predictor of OMD (r=.66 vs. -.45). IVDNFD was superior to IVOMD and all other analyses as a predictor of OMD (r=.84). OMI was best predicted by ADF (r=-.54).

Sixty of these hays were subjected to *in vitro* fermentation for 24, 36, 48, and 60 and 96 hr to determine potentially digestible (D) and indigestible (U) NDF, digestion rate constant (k_d) and digestion lag (L). A rumen passage rate constant (k_p) was estimated using D, k_d and NDF intake. Predicted NDF digestibility (NDFDP) was estimated as $Dk_d/(k_d + k_p)$. *In vivo* NDFD was more related to D than to NDFDP (r=.89 vs. .75).

Thirty-eight of these hays were analyzed for the phenolic acids, p-couramic and ferulic. Lignin and p-coumaric acid were about equally well correlated with NDF digestibility (r=-.72 and -.75), although p-coumaric acid represented an average of only 0.6% of NDF. Ferulic acid was not well related to any *in vivo* measures of forage quality.

We conclude from these studies that: (1) the relationship of Van Soest fiber fractions to forage quality differs in these tropical grasses from what is the conventionally accepted relationship; (2) the influence of rate of passage on variation in digestibility of tropical grass hays, fed *ad libitum*, may be marginal; (3) *in vitro* techniques remain the most accurate method for estimating digestibility; (4) further investigation into the nature of plant phenols and their relationship to forage quality is merited.

Key words: sheep, ruminant, forages, intake, digestibility, fiber, phenols, rate of digestion.

8-3-5

Structural Characteristics Limiting Digestion of Forage Fiber

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Cell walls of forages were studied for structural and chemical factors that limit digestion by rumen microorganisms. Techniques used to investigate digestion were histochemistry, electron microscopy, and anaerobic culturing of rumen populations on specific substrates.

Certain tissues such as the xylem cells totally resisted degradation by rumen microorganisms; these tissues stained positive for lignin with acid phloroglucinol (Weisner test). Other supportive tissues, such as the sclerenchyma in blades, stained positive for lignin with chlorine-sulfite (and also the Mäule test) and were also generally resistant to microbial digestion. Microscopic studies revealed that certain living tissues (i.e., those having cytoplasm and organelles indicative of metabolic activity) were only slowly or partially degraded in particular forage grasses, notably warm-season species.

Coastal bermudagrass and Boone orchardgrass, low- and high-digestibility grasses, respectively, were compared for the manner of attack by rumen microorganisms on digestible cell walls using electron microscopy. Tissues comprising about 70% of the cross-sectional area and including the mesophyll, phloem, parenchyma bundle sheath, and inner part of the epidermis in orchardgrass leaf blades were degraded often without the necessity of bacterial adherence, whereas only about 30% of the tissues, i.e., mesophyll and phloem, in bermudagrass blades were degraded in this manner. Although the percentages of the various types of adhering bacteria were similar with these forage species, more total bacteria associated with orchardgrass cell walls. Anaerobic culturing on media containing xylan, pectin, or cellobiose of bacterial populations adapted to orchardgrass or bermudagrass fiber resulted in larger total bacterial counts for orchardgrass-adapted populations; numbers of xylan-using bacteria were significantly ($P \leq 0.05$) higher. Further, the hemicellulolytic protozoan Epidinium ecaudatum forma caudatum degraded the mesophyll, parenchyma sheath, and epidermis of orchardgrass, but did not attack tissues of bermudagrass.

The data derived from electron microscopic and anaerobic culturing studies indicated that carbohydrates in bermudagrass fiber were less available to rumen microbial digestion than those in orchardgrass fiber. Histochemical studies with the chlorine-sulfite test indicated that certain living tissues (i.e., parenchyma bundle sheath) that were only slowly or partially degraded in bermudagrass were lignified which could explain the lack of availability of the carbohydrates within the cell walls to rumen microorganisms.

These data indicated that the carbohydrates, especially the hemicelluloses, in the digestible cell walls vary in their inherent availability to rumen microbial enzymes. Possibly, chlorine-sulfite lignin plays a significant role in limiting the rate of digestion of living tissue types in particular forages.

Key words: lignin, histochemistry, electron microscopy, digestibility, cell walls, rumen microorganisms.

8-4-1 Grazing Techniques for Evaluating Quality of Forage Cultivars in Small Pastures

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Animal performance is the ultimate measure of forage quality. Plant breeders have few laboratory analyses of forage quality that are good predictors of animal performance when grazing pasture. Our objective was to determine the feasibility of grazing small pastures with cattle in order to detect possible forage quality differences among cultivars of tall fescue (Festuca arundinacea Schreb).

Cultivars of 'Kentucky 31', 'Kenmont', 'Fawn' and 'Missouri 96' tall fescue and 'Kenhy' a Lolium-Festuca derivative were grown in 0.4 ha pastures at the University of Missouri Southwest Center. These cultivars represent a broad genetic base similar to that encountered in the evaluation of advanced strains in a grass breeding program. The experimental design was a randomized complete block with three replications.

Grazing periods ranged from 35 to 68 days for separate evaluations made during the spring, summer and autumn of 1974 through 1976. Between grazing periods, cattle grazed a reserve pasture of the same cultivar. All test pastures were grazed at the same grazing pressure. Equal grazing pressure was maintained by adjusting the area grazed using a forward and back electric fence or with put-and-take animals. Cattle were moved to a fresh paddock (strip) each week. Generally, pastures were grazed with three heifers during the spring and fall periods and by two heifers during the summer. Forage availability was determined from three m^2 quadrats/paddock clipped to ground level one day prior to shifting cattle to a fresh paddock. Residue herbage remaining after grazing was also determined. Pastures were irrigated two of the three years.

Significant differences were obtained in heifer average daily gains (ADG) among the five cultivars. Compared to 'Kentucky 31', the control cultivar, ADG's of heifers ranged from 22 to 83% greater on Kenhy and Missouri 96. Differences in ADG occurred mainly in the spring and autumn. There were no measurable differences in herbage intake.

Actual and estimated experimental errors for measuring ADG were very similar in all but two periods of grazing. This shows that the error estimate method of Petersen and Lucas is a useful tool for use in designing grazing trials to evaluate forage cultivars in small pastures.

Our results exhibit the importance of animal evaluation of new forage cultivars and the hazard of depending only on laboratory analyses as the bases of assessing forage quality. Since animal gain is a function of the amount of herbage consumed and its quality, we contend that equal grazing pressure must be imposed on all pastures to insure measurement of only forage quality differences.

Key words: tall fescue, Festuca arundinacea Schreb., cattle gain, experimental errors.

8-4-2

Screening Perennial Forages Using the Mob-Grazing Technique

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Many potential forages can be obtained in a short time through plant introductions and active breeding programs. Initially, these large numbers can be reduced through small plot studies, but the number of remaining entries may still be too large to evaluate in expensive grazing trials. Mob-grazing is a technique which allows the study of forage response to severe defoliation by grazing animals using a limited land area. Basic and applied forage management data may be obtained on many entries simultaneously. The mob-grazing technique was used to evaluate 16 subtropical grass entries (two *Digitaria* spp. one *Paspalum* sp. and 13 *Cynodon* spp.) in a split plot design, with four replications. Grazing frequencies of 2, 3, 4, 5 and 7 weeks were main plots with grass entries as subplots. Each grass occupied an area of 8 m^2. Grasses were sampled to determine total yield and forage quality [*in vitro* organic matter digestion (IVOMD) and crude protein (CP)] prior to grazing. Weed infestation was determined semiannually. Twenty five yearling crossbred cattle were used to rapidly consume (mob-graze) the forage leaving a stubble height of approximately 7.5 cm within 2 days. All grass entries were leveled to a 7.5 cm stubble with a rotary mower following the removal of cattle.

Average dry matter (DM) yield generally followed a quartic trend over grazing frequencies and increased as grazing frequency decreased from 2 to 7 weeks. A lowing these grasses a 4-week grazing frequency resulted in DM yield decreases for most entries. Decreasing the grazing frequency from 4 to 7 weeks resulted in a DM yield increase of 50 to 75% for most entries. Grazing at 4 and 5 week intervals resulted in the highest (42%) and lowest (22%) weed contamination, respectively, when compared with the other grazing intervals after 3 years. Decreasing the grazing frequency from 2 to 7 weeks resulted in a 6 and 10 percentage unit decrease in CP and IVOMD, respectively. A significant ($P<0.05$) grass entry by grazing frequency interaction was also evident for CP and IVOMD. 'Sarasota' stargrass (*C. dactylon* var. *coarsii*) and 'Alicia' bermudagrass (*C. dactylon* var. *elegans*) both averaged 10 to 15 percentage units lower in IVOMD than 'Puerto Rico' stargrass (*C. nlemfuensis* Vanderyst var. *nlemfuensis*) and the digitgrasses (*Digitaria* spp.). The 5-week grazing frequency resulted in high yields of quality forage with little weed contamination. These data suggest that several forage entries can be screened using grazing cattle on a limited land area. Furthermore, the effects of management practices on various forage indices (yield, quality, weeds, etc.) can be measured under conditions of severe defoliation by grazing animals.

Key words: mob-grazing, forages, screening, *Cynodons*, *Digitarias*, *Paspalum*, technique.

8-4-3 Effects of Stocking Rate and Climate on Regeneration of Perennial Grasses in Natural Pastures in Semiarid Southeastern Australia

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In principle, the maintenance of a particular species assemblage in a community depends on longevity of plants, opportunities during that life-span to produce viable seed, viability of seed in the soil, and opportunities for seed to germinate and establish. In some cases, however, regeneration may not occur even under favorable environmental conditions because the community is "closed" with no effective niches available for germinating seeds to occupy. An understanding of the process which determines or controls regeneration in plant populations is therefore an essential prerequisite to the formation of long-term management policies.

A significant result of a seven year grazing study conducted in central western New South Wales, Australia, was the relative stability in terms of total density of windmill grass (Enteropogon acicularis), which acted independently of grazing intensity. Further, even though several new cohorts were produced, density remained constant, a result which implies that when a mature windmill grass died, it was replaced by a member of the same species.

A major concern of this observation is that it may reflect only a temporary "stability," resulting from a series of favorable seasons in a continuing long-term process of pasture degeneration caused by grazing intensity. If there were a sudden decline in E. acicularis density would this open the way for an irreversible invasion by more competitive, but less stable species into vacated perennial niches, or would the observed replacement fidelity continue unchanged?

Our experiment was designed to test the hypothesis that the regeneration of windmill grass following the removal of mature plants was independent of grazing intensity. After initially removing plants by grazing at about 25 sheep/ha, subsequent regeneration and continued development of windmill grass seedlings were monitored in permanent quandrants under grazing intensities of 25, 37 and 49 sheep/ha. Pasture composition was determined by step point sampling throughout the study.

The results showed that pasture composition and windmill grass density were more sensitive to climatic influences than to grazing intensity. However, it was noted that the secondary grasses, Chloris truncata and Stipa variabilis increased their densities significantly. This indicates that previously established windmill grass plants controlled pasture change by creating a "closed" community for perennial species.

Key words: stocking rate, grazing intensity, regeneration, Enteropogon acicularis.

8-4-4 The Practical Applicability of Variable Stocking (Put-and-take) in Grazing Trials

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Variable stocking, as opposed to fixed stocking, aims at minimising the effect of non-treatment variables and maintaining the potential of the animal above that of the pasture in grazing trials. There is little information available, however, on how the method should be applied in practice, and to what extent it achieves its objectives. The aim of this paper is to examine availability per unit area (measured with the pasture disk meter) as a criterion for adjusting animal numbers in variable stocking trials, and on this basis, to assess the practical applicability of variable stocking, and to what extent it achieves its objectives relative to fixed stocking.

In one trial linear regressions were established between availability and animal weight gain for two pasture grasses. Fixed and variable stocking were then applied to the two species in a second trial to establish to what extent variation in availability could be controlled by variable stocking.

Correlation coefficients of regressions between average daily gain and availability were significant ($P = 0,001$). Weight gain was sensitive to availability which was easily measured with the pasture disk meter. Hence the use of availability as a basis for adjusting animal numbers in variable stocking trials was justified. Variable stocking appeared to be unsuccessful in controlling variation in availability with time, relative to fixed stocking, but seemed to reduce the variation between treatments and replications. Since fixed stocking requires less attention, from a practical point of view, it is doubtful in many situations whether variable stocking should be applied in preference to fixed stocking, unless differences are likely to be large.

Key words: variable stocking, fixed stocking, disk meter, pasture availability.

8-4-5- A Mathematically and Conceptually Unified Approach to Grazing Management Terminology

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Expressions such as stocking density, stocking rate, grazing pressure, herbage allowance, grazing intensity, stocking intensity and stocking pressure have long been used to describe animal pasture systems. In general, these expressions describe relationships among the basic variables of animals, forage quantity, pasture area and grazing duration. Our objective was to develop a conceptually dynamic, mathematical framework of expressions summarizing all of the meaningful relationships among these variables. Elementary differential and integral calculus were used to develop this dynamic and unified framework.

The resulting expressions are dimensionally valid, and are capable of accurately describing dynamic animal-pasture systems. Hopefully, this work will result in increased standardization in the use of these technical expressions, and in the elimination of other dimensionally invalid expressions found in the literature.

Key words: grazing terminology, animal-unit, animal-unit-equivalent stocking rate, grazing pressure, grazing modeling.

8-5-1

Influence of Sward Structure upon Herbage Intake of Cattle Grazing a Perennial Ryegrass Sward

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A trial was undertaken to examine the possibility that the structural distribution of herbage within a sward will influence intake.

Two swards of contrasting structure were established at two periods in the grazing season by either infrequent mowing (C) or hard sheep grazing (G) of a perennial ryegrass (Lolium perenne) pasture. The plots were then allowed to grow undisturbed for about 5 weeks before being grazed by young cattle for periods of a fortnight at two levels of herbage allowance, 30 and 60 g DM kg LW^{-1} d^{-1}, in July (Period 1) and September (Period 2). Detailed measurements of sward structure were made by stratified cutting of the pasture. The herbage intake of the cattle was measured both by the chromic oxide dilution technique and by cutting quadrats from the pasture before and after each day's grazing.

Quantitative and qualitative descriptions of the whole sward and of the six strata within it are presented. Two contrasting pairs of swards were evident: only 30% of the total herbage mass was above 5 cm in swards 1G and 2C, whilst 50 and 60% were above this height for 1C and 2G. Both previous pasture management and herbage allowance affected intake. The cutting technique gave a 16% lower estimate of intake than did the chromic oxide technique. Animals grazing sward G consumed 10% less grass than those on C but these differences were far greater at the low than the high allowance (16 v 5%). The intakes at the low allowance were 21% less than those at the high.

Differences between herbage intakes on swards G and C occurred mainly in the low allowance groups. Bulk density did not have a strong influence upon intake and it was concluded that the presence of sheep excreta had the predominant effect. It is suggested that in future studies a multivariate approach in which a range of pasture characteristics is studied would be more satisfactory than a factorial design.

Key words : cattle, grazing, ryegrass, intake, sward structure.

8-5-2 Formation of Volatile N-nitrosamines in Silages

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During the past 15 years several statements have caused a sensation concerning the carcinogenicity of N-nitroso compounds. Especially the N-nitrosamines have been in the centre of interest.

Both exogenous sources (direct intake of nitrosamines with feedstuffs, pharmaceuticals, air, and soil) and endogenous ones (in vivo formation of nitrosamines from the precursors nitrate, nitrite, and nitrosable amino moieties, especially in the digestive tract) seem to be responsible for nitrosamine contamination of animals.

Amino moieties suitable on principle for nitrosation into nitrosamines include secondary and tertiary amines as well as quaternary ammonium compounds. In that context, special importance is attached to the secondary amines since their representatives are ubiquitous.

The rate of nitrosation is essentially dependent upon the concentration of the starting material and the pH of the reaction medium. Nitrosation proceeds the easier the less the amines are alkaline, with basicity being increased by alkyl groups and reduced by phenyl groups.

The carcinogenicity of N-nitrosamines decreases with increasing alkyl chain length and decreasing basicity; no carcinogenic effect is found, however, in nitrosamines having no free hydrogen in α-position to nitrogen.

The above conditions are found first of all in the case of malfermentation of silages. In 1978, TERPLAN et al. detected nitrosamines a.o. in five of ten silages from beet tops, maize, and grass. Statements from Poland (JUSZKIEWICZ and KOWALSKI, 1972, 1974, 1978) have shown that nitrosamines orally administered to ruminants and hens can be detected in milk and eggs for up to 36 hours (milk) and, according to the applied doses, up to 14 days (eggs), respectively.
Preliminary investigations made by the authors have shown that malfermented silages containing butyric acid included volatile nitrosamines (dimethyl- and diethyl nitrosamines) in substantial quantities. After feeding these silages to dairy cows, the carcinogenic substances were detected in the milk. Analytical methods used include gas chromatography/thermal-energy analyzer, mass spectrometry, and microbiological/biological tests.

Key words: nitrosamines, silage, milk.

8-5-3 Duodenal Amino Acid Supply of Lactating Ewes Fed Coast Cross Bermuda Grass Forage (Cynodon dactylon)

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Four lactating cows of 450 kg live weight, cannulated in the rumen and duodenum and fed Coast-cross bermuda grass forage were used in order to measure the supply of amino acids to the duodenum. The animals were producing between 3.3 and 6.6 liters of milk per day. Duodenal flow was measured by continuous infusion of the soluble marker Cr-EDTA. The solid fraction flow was determined by chromic oxide in one of the animals. Samples from the duodenum were taken at regular intervals for amino acid determination and Cr. DM intake was 2.4 to 3.0% of live weight. The amino acids of higher concentration in the forage (g/kg DM) were aspartic (8-11), glutamic (8-12) and leucine (6-8) and those with lower concentration were histidine (1-3), tyrosine (2-3), methionine (2-3) and cystine (1-3). DM and OM apparent digestibilities at the level of duodenum were 55 and 57%, respectively. The amounts of arginine, histidine, lysine and methionine flowing through this organ per day were 2 to 4 times higher than the tabulated requirements of metabolizable amino acids. It is considered that the amino acids supplied from forage diets to the duodenum with moderate contents of protein are adequate to sustain milk production levels of the order of 15 to 20 liters/day.

Key words: amino acids, duodenum, lactating cows, Cynodon dactylon.

8-5-4 Relationship between Fecal Components and Green Forage Digestibility and Consumption in Beef Cattle

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A limitation of nutritional research with grazing ruminants under extensive pasture conditions is that no reliable and simple technique for measuring forage ingestion or digestibility of forage ingested by undisturbed animals is available. The purpose of this research was to relate an array of selected fecal components to green forage intake and digestibility and thus to determine the feasibility of ultimately developing fecal indices of broad application. Data from two total collection in vivo intake and digestion trials totaling 55 determinations were analyzed. For the trial conducted in 1978, 38 determinations with eight steers averaging 218 kg were made on fescue (F. arundinacea Schreb.) and fescue-legume (legumes were Trifolium incarnatum, Trifolium pratense L. and Lespedeza stipulacea Maxim.) mixtures during grazing season. For the trial conducted in 1979, 17 determinations with eight steers averaging 303 kg were made on mixtures of Dactylis glomerata L., Phleum pratense L., T. incarnatum and T. pratense during spring and summer. These methods provided an array of forage qualities. Composite fecal samples were analyzed for dry matter (DM), Proximate analysis, Van Soest fiber analysis, Na, Zn, Mg, Cu, K, Fe, Mn, P, Ca, density and acid detergent fiber nitrogen (ADFN). Samples were also dry-sieved after grinding through a 1 mm screen and modulus of fineness calculated. Non-ADFN (NADFN), cellulose (cell) and hemicellulose (hemi) were also calculated. Trial, animal and seasonal effects on DM intake, (DMI), DM digestibility (DMD), fecal DM output (FDMO) and digestible DM intake (DDMI) were accounted for by developed indices. Simple product-moment correlation coefficients indicated that the fecal components related ($P<.05$) to DMI were nitrogen (N), ether extract (EE), nitrogen free extract (NFE), Zn, ash, Mg, Cu, modulus of fineness at .5 mm screen (MF.5MM), Ca, and NADFN; those related to DMD were N, EE, acid detergent fiber (ADF), cell wall constituents (CWC), cell, NFE, Na, Zn, Mg, Cu, K, ADFN, MF1MM and NADFN. The best (highest R^2) multiple regression equations for prediction of DMI, FDMO, DMD and DDMI had R^2 (and residual standard deviations (RSD)) of .74 (.64 kg/day), .65 (.22 kg/day), .75 (6.51%) and .76 (.57 kg/day). These were the best 10 variable models of which only 6, 8, 6 and 8 variables were related ($P<.05$) to DMI, FDMO, DMD and DDMI respectively. When interactions were included for important ($P<.05$) main effects, a usable model for predicting DDMI was: DDMI = 8.60 + 0.03(CWC) -0.17(LOGN) -0.63(ash) -4.58(Mn) -0.18(CWC x LOGN) -0.001(CWC x ash) +0.07(CWC x Mn) +0.94 (LOGN x ash) +4.48(LOGN x Mn) (R^2=.78,RSD=.54). The equation: DDMI = -1.30 + 1.40 (N) had an R^2 of .50 and an RSD of .75 kg/day. Fecal N indices have been shown by many workers not to have broad application because the relationship between fecal N and forage intake or digestibility change as to season of year, N in forage and species consumed, but the addition of EE, CWC, DM and certain minerals to models containing N largely overcomes these problems. Therefore, the development of usable fecal indices of fairly broad application appears possible.

Key words: fecal index, digestibility, intake, pasture nutrition, beef cattle.

8-5-5 Scientific and Practical Aspects of Utilization and Evaluation of Protein Quality in Fodder

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This report summarizes 10-15 years of research on fodder quality. The most promising directions of investigation into this field have been determined and a critical analysis of the existing systems of fodder evaluation will be presented.

Three main aspects of utilization and evaluation of fodder protein quality are considered.

1. Change in the fodder protein quality in connection with agronomics practices of crop cultivation and various technologies of their conservation. It has been shown that fodder protein quality depends on botanical composition of pasture grasses, levels of mineral and nitrogen fertilization, frequency of cutting, etc. The influences of different levels of grass wilting, regimes of artificial drying, pelleting, wafering, ensiling, chemical preservation, and haylage-making on the extent of protein damage have been determined. It has been established that changes in protein quality depend on the conditions and duration of fodder storage.

Using surgically modified animals, the process of transforming protein from fodder prepared by different technologies has been studied. The efficiency of fodder protein utilization depends on the physical structure and methods of processing of the fodder. Experimental data obtained show significant difference in effectiveness of protein utilization for milk production among various types of fodder prepared from the same material.

2. Chemical and biological methods of evaluating fodder protein quality for ruminants: Protein quality of various types of fodder was evaluated by indices of amino acid analysis, protein solubility, and nitric nitrogen content. Protein quality constants for pasture grass and preserved fodder were estimated.

Biological evaluations included investigations with laboratory animals (*Cavia porcella*), sheep and cattle. The present state of biological methods of evaluating protein quality of fodder has been analyzed and promising directions of future investigations in this field have been determined.

3. Comparative evaluation of various methods of fodder digestibility. A number of *in vitro* methods of determining fodder digestibility have been compared with the standard Tiley and Terry method and possible ways for their improvement and wide use in practice are outlined.

Key words: protein quality, processing methods, storage, *in vitro* digestibility, biological value, forage.

8-6-1 Forage Analysis with Near-Infrared Reflectance Spectroscopy: Status and Outline of National Research Project

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Objectives of this paper are to review the status of near-infrared-reflectance spectroscopy (NIRS) in forage-quality evaluation and to indicate the approach being used in a national research effort to further test, validate, and develop the technology for use in forage breeding, production, and utilization programs. Use of NIRS assay of forage quality was first reported five years ago. Research has now been initiated at a large number of locations.

A national research project, involving personnel at six widely dispersed locations in the U.S., was established in 1978. Computerized high-precision, near-infrared reflectance spectrophotometers are employed. A set of 30 forage samples provided experimental materials to ascertain magnitudes of errors involved in chemical, in vitro digestibility, and NIRS analyses at the six laboratories.

The six instruments showed different average spectral curves, but normalization of the data resulted in curves essentially alike except for the bands affected by water, an effect caused by differences in moisture content of the samples at the different sites. Our studies indicate that the magnitude of the errors associated with NIRS analysis compare favorably with those found in routine chemical and in vitro procedures.

Examples of research findings involving different plant species, harvests, growth environments, and drying procedures are presented. The results show that for maximum accuracy the calibration samples should be representative of the forages for which quality will be predicted by NIRS.

Key words: forage quality, chemical analysis, crude protein, neutral detergent fiber, acid detergent fiber, acid detergent lignin, in vitro dry matter disappearance.

8-6-2

Prediction of Forage Quality with NIR Reflections Spectroscopy

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Near-infrared (NIR) reflectance spectroscopy can be used to predict the quality of forages and their chemical composition. Studies were conducted on warm-season grasses with a filter type NIR reflectance spectrometer, to evaluate the NIR technique and the tilting filter spectrometer. Freeze-dried, hay and drum-dehydrated samples of bermudagrass and bahiagrass were used. A monochrometer NIR reflectance spectrometer was used to narrow the possibilities of wavelengths to be investigated. The following compositional and quality parameters were determined: crude fiber (CF), fat, acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), true protein, i.e., trichloro-acetic acid precipitated protein (TP), permanganate lignin (PML), acid insoluble lignin (AIL), in vitro dry matter disappearance (IVDMD), and in vivo digestibility (DDM).

For freeze-dried bermudagrass samples, the standard errors of calibration and prediction were fairly close to normal laboratory results (CP 1.01 and 0.58; TP 0.79 and 0.83; ADF 1.78 and 1.07; NDF 2.78 and 2.77; PML 0.54 and 0.66; and IVDMD 3.37 and 1.90, respectively with 28 samples in the calibration set and 11 in the prediction set). The results of bermudagrass hays (20 for calibration, 22 for prediction) were similar with standard errors of calibration and prediction of CP 1.15 and 0.84; ADF 2.46 and 1 42; NDF 2.06 and 1.39; AIL 0.50 and 0.51; and DDM 1.78 and 2.54, respectively. When drum-dehydrated samples were examined, wavelengths chosen for the freeze-dried and hay samples did not give satisfactory standard errors of prediction. New wavelengths were chosen and the standard errors of calibration and prediction were CP 0.87 and 0.89; CF 0.54 and 1.54; and fat 0.73 and 0.37, respectively, with 20 samples in calibration set and 26 in the prediction set. All of these analyses were made using a second derivative mathematical treatment. The use of a delta OD at one wavelength divided by delta OD at another wavelength ($\Delta OD_1/\Delta OD_2$) mathematical treatment improved the standard errors of calibration and prediction of CP for drum-dehydrated bermudagrass (CP 0.58 and 0.61, respectively). Current work with bahiagrass shows similar errors of calibration and prediction. A new monochrometer instrument which is part of the National Forage NIR network is being used to improve the technique and expand the scope of this method of forage evaluation.

Key words: near-infrared reflectance spectroscopy, NIR, forage quality analysis, forage compositional analysis.

8-6-3 Relationships between the Properties of Southern U. S. Forages and Animal Response

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Objectives of Southern Regional Project S-45 were to examine (1) quality-related characteristics of forages in the southeastern U.S. and (2) inter-laboratory variations in *in vivo* and chemical data. Hays were produced and fed to cattle and/or sheep in eight states, and analyses were conducted in 11 laboratories. There were 66 hays representing 10 cultivars, four types (alfalfa, temperate perennial grasses, tropical annual grasses and tropical perennial grasses), three stages of maturity, and, in some cases, two locations. Six of the hays were exchanged among three states for *in vivo* comparisons.

Average daily gain (ADG) was measured on 42 hays, and they ranged from -.27 to .89 kg. Voluntary intake was measured on 53 hays, and dry matter (DM) intake ranged from 55 to 116 g/kg metabolic weight ($W^{.75}$). Digestion trials were conducted on 62 hays, and DM digestibility ranged from 44 to 71 . There were main effect differences ($P<.01$) due to maturities and cultivars in ADG; intake of DM and digestible DM, and digestibilities of DM, neutral-detergent fiber (NDF) and acid-detergent fiber (ADF). Across all hays, ADF intake was the least variable intake measurement; only cultivars differed ($P<.05$). In the exchange study, there were differences ($P<.01$) among states in ADG, DM intake and NDF digestibility.

Intake of DM was correlated with DM digestibility ($r = .69$, $P<.05$). Digestible DM intake was correlated ($r = -.83$) with undigestible NDF (as of DM, based on *in vivo* digestibility). Digestibility of DM was correlated with digestibility of NDF ($r = .73$) and of ADF ($r = .77$).

There were main effect differences ($P<.01$) due to maturities, cultivars and laboratories in chemical composition and *in vitro* digestion, and *in vitro* digestion showed hay by laboratory interactions ($P<.01$). Using across-laboratory means, NDF was correlated with ADG ($r = -.59$), DM intake ($r = -.41$) and DM digestibility ($r = -.61$). However, ADF was more highly correlated than NDF with DM intake ($r = -.65$) and DM digestibility ($r = -.71$). Correlations (r) between *in vivo* and *in vitro* digestion ranged from .68 to .93 among laboratories.

Improvement of animal performance on southern forages will depend upon overcoming limitations of cell-wall utilization. Broad application of prediction models will require more attention to inter-laboratory variations.

This report is on behalf of all members of the Regional Project Technical Committee. The committee thanks A.C. Linnerud and R.J. Monroe for statistical analyses.

Key words: hay, quality, gain, intake, digestibility, composition, *in vitro*, correlations.

8-6-4 Proposed Hay Grading Standards Based on Laboratory Analyses for Evaluating Quality

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The progress report of the Forage Analysis Subcommittee of the Hay Marketing Task Force organized by the American Forage and Grassland Council (J. Anim. Sci. 47:1978) proposed new hay standards that will more adequately express feed value and communicate this value more fully to all concerned. The subcommittee studied the potential for expanding the standards to include legume-grass mixtures; however; individual legume and grass equations gave more consistent predictions of quality. Digestibility and dry matter intake by cattle and sheep were compared when fed the same forages. Digestibility was nearly identical for both livestock species; however, cattle were somewhat more efficient in utilizing low quality legume and legume-grass forages than were sheep but not with grasses. Regressions combining legumes and grasses are proposed.

Key words: acid detergent fiber, neutral detergent fiber, forage quality, market hay grades, relative feed value.

9-1-1

The Potential of Forage Legumes and Their Role in Scotland

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Intensive forage production requires fertilizer nitrogen (N), whose manufacture depends upon fossil fuel energy. Increasing energy costs and possible scarcity raise doubts about the future. The known ability of legumes to fix atmospheric N, together with better varieties and new conservation techniques, has stimulated renewed research into forage legume production. A further stimulus is the high value of leguminous forage for animal production.

Various aspects of the agronomy of forage legumes have been studied in recent years at The West of Scotland Agricultural College. As part of this programme an experiment was established in 1978 to examine the effect of applied N level (0, 120, 240 and 360 kg ha^{-1} $annum^{-1}$) and closeness of cutting (4 and 8 cm from ground level) on four white clover varieties of differing morphology. A simulated grazing regime with six defoliations was employed. In addition two experiments involving white clover, diploid and tetraploid red clovers and lucerne were established in 1979. In one, the effect on production of five companion grasses of differing competitive ability (timothy, meadow fescue, sweet brome and diploid and tetraploid perennial ryegrasses) was assessed. In the other, the same four legumes were sown alone and in different combinations. The cutting regime in both these experiments was simulated conservation with three harvests over the season. No fertilizer N was applied.

In the white clover experiment, mean total herbage DM responded to increasing level of applied N, from 7.62 t ha^{-1} $annum^{-1}$ at nil N to 12.30 t ha^{-1} at 360 kg ha^{-1} N. Clover contribution declined as fertilizer N level increased. Close defoliation increased both total herbage and clover herbage DM yields. The larger-leaved varieties (Olwen and Linda) gave most DM but the absence of variety x applied N interactions suggested that varieties did not differ in tolerance to applied N.

When the different legumes were grown with various companion grasses, red clover at 15.99 t ha^{-1} DM had a clear yield superiority over lucerne (10.38 t ha^{-1}) and white clover (9.55 t ha^{-1}). Annual DM yield differences between legume/grass mixtures were small (mean, 13.36 t ha^{-1}) but all were superior to clover alone (12.10 t ha^{-1}).

Red clover in a legume mixture tended to dominate other legumes and annual DM yields ranged from 14.46 to 16.16 t ha^{-1}. Red clover sown alone also outyielded lucerne and white clover. Inclusion of white clover depressed DM production but increased organic matter digestibility where it made up a substantial content of the sward.

Continued research in Scotland to increase the efficiency of use of white clover and reduce its production variability is required. Further assessment of the potential of red clover is also necessary, but only limited work on lucerne, birdsfoot trefoil and forage peas is justified. The future role of forage legumes is to substitute for or complement manufactured nitrogenous fertilizers and provide high quality forage. Their exploitation will also be dependent on how well they can be integrated into farming systems.

Key words: forage legumes, herbage production, quality, future role.

9-1-2

Legume Introduction and Maintenance in Hill Pastures

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Forage production from hill pastures is often low and of poor quality. Increasing the legume component of such pastures can lead to improvements because of increased atmospheric nitrogen (N) fixation and because legumes are usually better quality feed. In this experiment three methods of seeding three legumes into a hill pasture were examined. These were broadcasting the seed by hand, sod seeding with a Zip seeder and sod seeding with a power-till seeder. The legumes used were red clover (Trifolium pratense), white clover (T. repens) and birdsfoot trefoil (Lotus corniculatus). The effects of paraquat (1,1'dimethyl-4,4' bipyridium dichloride) and soil amendment (phosphorus (P) and lime) on legume establishment were also examined. Two nonseeded control treatments were included, N (112 kg/ha/year) and nothing.

The experimental area was a Kentucky bluegrass (Poa pratensis)/ Agrostis spp. pasture with up to 15% slope; initial soil pH was 4.8 and soil P was low. The experiment was designed as a randomized complete block with split plots, three blocks and two replications per block. Subplots were 1.8 x 3.0m in size. Cows and calves grazed the experiment as one paddock every time the pasture reached a height of 10-15 cm. Botanical composition was noted visually for a three year period.

Seeding increased the percentage of legumes in the first and second years, but had no significant effect in the third year. The best method of seeding was with the power-till seeder. While plots in which legumes were established by broadcasting or using the Zip seeder were lower in percentage of legumes than those in which the power-till seeder was used, the former two methods of establishment were satisfactory. Seeding with red clover increased the total legumes in the plots to 40% in the second year. However, in the third year the percentage of legumes in all seeded plots was similar. Paraquat increased the percentages of legumes, weeds and bare ground in the first two years. In all three years lime and P increased the percentage of legumes and decreased the percentages of grass, weeds and bare ground.

The results of this experiment indicate that legumes may be successfully introduced into a hill pasture without the use of a seeder. The use of a power-till sod seeder or paraquat may give higher percentages of legumes than broadcasting during the first two years. Of the factors tested only lime and P can be expected to have any lasting effect on legume content of hill pastures.

Key words: legumes, establishment, hill pastures, red clover, birdsfoot trefoil.

9-1-3

Techniques of Overdrilling for the Introduction of Improved Pasture Species in Temperate Grasslands

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Experiments over several years are summarised. Collectively, these experiments sought to improve the reliability of overdrilling techniques during growth periods of temperate swards. The studies firstly sought to identify the important physical requirements of seeds and seedlings in untilled soils, especially in unpredictably dry situations; and thence to develop drilling machinery and techniques to more nearly fulfil these requirements than had hitherto been achieved in New Zealand.

The studies firstly involved closely controlling and monitoring the drilling and seed-groove-covering procedures, the soil moisture status and mechanical properties, and post-drilling climates, using a tillage bin technique. Cereal seeds were drilled into large undisturbed blocks of soil contained in steel bins, which were then placed in controlled climate rooms for seedling emergence and groove micro-environment studies. Subsequently, field trials with pasture and crop species sought to extrapolate these data to the variable oceanic climate and soil conditions of New Zealand, which lies geographically between latitudes 35° and 48° South.

The importance of the drilling techniques and equipment was highlighted in dry soils. Contrasting designs of groove openers and covering devices had less effect on seed germination than on sub-surface seedling survival and emergence. The more traditional "V" or "U" shaped seed grooves consistently promoted less seedling survival (even when covered with loose soil) than where soil disturbance was largely confined to a sub-surface layer, with a narrow surface slit and an overlay of dead vegetative mulch.

Two designs of drill openers, a bar covering harrow and several press wheel designs were developed. The main effect that this improved equipment had was to improve the in-groove seedling habitat. An experimental chisel opener (with sub-surface wings) and bar harrow combination significantly ($P < 0.01$) decreased the rate of loss to the atmosphere of in-groove humidity by 45% compared to a triple disc opener; and 16% compared to a hoe opener, both in association with the bar harrow. Press wheels operating on the seeds at the bases of the grooves before covering, improved seedling responses for the triple disc and hoe openers. A moderate correlation coefficient, $r = 0.75$, between the mean loss of in-groove humidity for six days, and sub-surface seedling survival was established across the three opener designs.

Physical removal of a strip of the competing resident sward overlying the drilled grooves, clearly contrasted with the desirability of retaining a mulch as a major component of the groove cover for moisture retention. A simultaneous band spraying technique was evolved and tested, using paraquat and/or roundup (glyphosate) applied in strips either ahead of, or following the openers. Vigour of introduced species was related to the width and effectiveness of the herbicide bands.

Key words: drilled groove, seed habitat, seedling habitat, drilling equipment, band spraying.

9-1-4 Reduced Tillage Pasture Renovation in the Semi-Humid, Temperate Region of the United States

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A series of studies conducted in Iowa has shown that precision seed placement, good seed-to-soil contact and reducing competition from other species are just as important when introducing legumes into an existing grass sward as when seeding into a conventional seedbed.

Tillage of 5.1 cm wide strips or wider was necessary for adequate sward suppression prior to and during legume establishment. Paraquat (1,1' di-methyl, 4,4' bipyridilium) at 2.8 or 5.6 kg/ha could substitute for strip tillage in sward suppression. Paraquat banded over the seeded row provided satisfactory sward suppression but legume establishment was improved when paraquat was broadcast applied or glyphosate (N-(phosphonomethyl)glycine) was band applied. Improved stand densities were obtained when precision placement of seed and press wheels were used compared with surface seeding with shallow coverage and no soil firming over the seed.

Alfalfa (Medicago sativa L.), birdsfoot trefoil (Lotus corniculatus L.) and crownvetch (Cornilla varia L.) have all been successfully established in existing pasture swards via reduced tillage renovation techniques.

Post-seeding sward height management significantly influences the rate of legume establishment in the renovated swards. The greater light availability for a Bromus-dominated sward managed at a 7.5 cm height resulted in greater legume stand densities, subsequent dry matter yields and legume percentage in the sward than did swards managed at greater heights.

In the year following renovation, dry matter yields of legume renovated swards was similar to that of swards fertilized with 75 kg/ha of nitrogen, with a greater proportion of the total yield produced during the summer and early autumn months.

Key words: pasture renovation, interseeding, paraquat, glyphosate, Lotus corniculatus L., Medicago sativa L., Cornilla varia L.

9-1-5 Introducing Clovers into Grass Swards by Slot-seeding (No-Till)

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Less than 20% of British grassland contains adequate amounts of white clover (Trifolium repens). In seeking low-cost methods of introducing clover seed into live swards, with the objective of increasing soil fertility, pasture quality and animal output, a partial no-till seeding technique has been developed. This involves cutting and removing a slot (hence the name) in the turf accompanied by band spraying a grass-suppressing herbicide and the simultaneous sowing of seed, fertilizer and pesticides.

During the development of the technique, instances of poor establishment, associated with certain sward types, prompted us to compare the damaging effect of the major grasses on the growth of slot-seed white clover. In addition we carried out a field experiment aimed at measuring the benefits of slot-seeding red clover (T. pratense) into a thinning perennial ryegrass (Lolium perenne) sward.

White clover. By digging up monoculture turves of various grass species, slot-seeding them with white clover and measuring germination, establishment vigour and dry matter yield it has been possible to show that red fescue (Festuca rubra) is particularly damaging to the growth of clover seedlings. Root competition seems to be the main operative mechanism but phytotoxic damage may also be involved.

Red clover. In April 1979 seed of Hungaropoly red clover was slot-seeded at 8 kg/ha into a 3-year-old ryegrass sward, aided by a band-spray of either paraquat or glyphosate, each at 2 rates and 2 widths (7.5 and 15 cm). Two harvests were taken in 1979 and 3 in 1980. Both herbicides significantly increased clover dry matter yields, compared with non-sprayed controls, especially glyphosate at 15 cm band-width. Moreover, total herbage harvested from the slot-seeded areas was equivalent to the dry matter yield of all-grass plots receiving a total of 160 to 210 kg N/ha.

We conclude that clover slot-seeding has a tremendous potential for the long-term improvement of certain types of permanent grassland, especially if N fertilizer costs continue to increase.

Key words: slot-seeding, white and red clover (T. repens, T. pratens), perennial ryegrass (Lolium perenne), red fescue (Festuca rubra) paraquat, glyphosate, nitrogen.

9-2-1 Establishment of Legume-Grass Mixtures Conventionally and by Minimum Tillage Methods

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Hilly terrain and rocky soils make it difficult to conventionally renovate forage-producing land in the Northeastern United States. Methods of introducing improved forage species with a minimum of tillage offer obvious advantages, yet there remains some question as to the effectiveness of surface-applied lime and fertilizer.

The objective of this study was to compare establishment and productivity of two forage mixtures established by conventional and minimum tillage methods. Mixture 1 was alfalfa (Medicago sativa L.) and orchardgrass (Dactylis glomerata L.). Mixture 2 was birdsfoot trefoil (Lotus corniculatus L.) and timothy (Phleum pratense L.).

The field renovated was predominately annual grasses and broadleaf weeds. The ph was 5.7 in the surface 5 cm and 5.3 at the 5-15 cm depth. Levels of available phosphorus and potassium were low. Dolomitic lime was applied in August 1976 at 0(L-1), 4.5(L-2), and 9.0(L-3) t/ha. Lime was incorporated on plots seeded conventionally and was left on the surface on plots seeded with minimum tillage. Fertilizer was uniformly applied before seeding on May 5, 1977.

All species established more quickly with conventional than with minimum-tillage seeding. Ten weeks from seeding alfalfa and orchardgrass dry matter yields were 1.36 and 0.20 t/ha greater, respectively, with conventional than with minimum-tillage establishment. At 13 weeks birdsfoot trefoil and timothy dry-matter yields were 0.60 and 1.05 t/ha greater with conventional seeding. There were substantially more annual weeds at the initial harvest with conventional establishment, 0.85, compared with 0.15 t/ha with minmum tillage establishment.

Forage yields were greater with conventional than with minimum tillage establishment the seeding year, except with Mixture 1 and L-1; the difference in yield was greatest at the highest lime level. Mixture 2 was higher yielding under conventional seeding without lime, while Mixture 1 responded more favorably to lime application. Forage mixtures established by minimum tillage responded with yield increases to the L-2 level of lime the year of seeding, but not until the third year of production at L-3.

In 1978 and 1979 dry matter and protein yields were similar for the two methods of renovation with L-2 and L-3. With Mixture 1, 4.5 t/ha of lime increased 3-year accumulated forage yield 53% with conventional and 29% with minimum-tillage renovation. Response from 4.5 t/ha of lime with Mixture 2 over the 3-year period was 19% with conventional and 20% with minimum-tillage establishment. At the end of three years legumes represented greater than 50% of forage yields, except for Mixture 1 seeded conventionally without lime (38%).

Although forages established more slowly by minimum tillage on this marginally fertile soil, legumes became established and persisted so that forage and legume yields were similar to those with conventional renovation the second and third years following seeding. On the basis of this study, minimum-tillage is an agronomically feasible alternative to conventional renovation and, because of lower energy and labor requirements, is becoming more economically desirable.

Key words: Medicago sativa L., Lotus corniculatus L. Phleum pratense L., Dactylis glomerata L., minimum tillage, yields, liming.

9-2-2 Influence of Pesticide, Fertilizers, Row Spacings and Seeding Rates on No-Tillage Establishment of Alfalfa

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No-tillage forage seedings can reduce soil erosion, conserve soil moisture, and lower fuel requirements but seeding failures still occur. There is a critical need to identify techniques that increase the frequency of successful no-till alfalfa (Medicago sativa L.) seedings. Failures are frequently blamed on some aspect of weather but other factors such as insects, nematodes and molluscan pests are undoubtedly involved.

Two experiments were established in September, 1979, to investigate seeding techniques associated with no-tillage establishment of alfalfa in barley (Hordeum vulgare L.) stubble.

The objective of experiment one was to evaluate the influence of carbofuran insecticide/nematicide and phosphorus (P) and nitrogen (N) fertilizers on seedling weight, plant population and forage yield. Plots were seeded with a Tye Pasture Pleaser drill. Treatments were: (1) check; (2) 27.5 kg P_2O_5/ha; (3) 2.2 kg ai/ha carbofuran (granular); (4) 2.2 kg ai/ha carbofuran + 27.5 kg P_2O_5/ha; (5) 2.2 kg ai/ha carbofuran + 27.5 kg N/ha; and (6) 2.2 kg ai/ha carbofuran + 27.5 kg P_2O_5/ha + 27.5 kg N/ha. All materials were applied in the row with the seed. The largest seedlings at 10 weeks after seeding occurred with carbofuran + P + N. The smallest seedlings were associated with the check and P treatments. The highest plant populations at 6 and 30 weeks after seeding occurred where carbofuran and carbofuran + P were applied. The smallest plant populations occurred with the check and P treatments, while the carbofuran + N and carbofuran + P + N were intermediate. Carbofuran and carbofuran + P produced the highest dry matter yields at first harvest. Yields of the check and P treatments were significantly lower than any of the other treatments. Dry matter yields for the four treatments containing carbofuran were not significantly different at second harvest, but they were about double the yields of the check and P treatments.

The objective of experiment two was to examine the relationships of seeding rates and row spacings to seedling weight, plant population, weed competition and forage yield. Plots were seeded using a Moore Uni-drill. Row spacings evaluated were 12, 24 and 36 cm. Seeding rates were 5.5, 8.2, 16.5 and 33 kg/ha. Seeding rates affected plant population and forage yield but had no significant effect on seedling size as measured by seedling weight 10 weeks after seeding. The 33 kg/ha seeding rate resulted in a significantly higher plant population at 30 weeks after seeding; however, there was no significant increase in forage dry matter yield over either the 16.5 or 8.2 kg/ha seeding rates. The 5.5 kg/ha seeding rate yielded significantly less than the other seeding rates. At a seeding rate of 16.5 kg/ha, there were no significant differences in seedling weight, plant population, or in forage dry matter yield due to row spacings of 12, 24 and 36 cm.

Key words: alfalfa, Medicago sativa L., carbofuran, no-tillage, seeding rates, row spacings, nitrogen, phosphorus, pesticides.

9-2-3 Structure and Produce Ability of Phytocoenosis of Permanent Grasslands with Long-term Nitrogen Fertilization

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In 14-year trials carried out in the most extended types of permanent grasslands in the potato growing region (annual precipitation 550-770 mm, temperature 6.6-7.8°C), the influence of graduated level of N-fertilization (0-100-200-300-400 kg N, 40 kg P and 100 kg K/ha) on botanical composition and profitability of grasslands and soil property and leaching of essential plant nutrients, was researched. Systematic N-fertilization supported temporarily the evolution of loosely tufted tall growing grasses that were gradually replaced by rhizome-forming grasses at the beginning of the 4-6 years of fertilization. The domination of rhizome-forming grasses was directly proportionate to the N application rates, and after 14 years it was 27-50-73-78%. At the stage of rhizome-forming the main species were Alopecurus pratensis, Festuca rubra ssp. genuina, Poa pratensis and Agropyrum repens. Extension of Agropyrum repens means the degradation of a grassland. It can limit the effects of N application rates on the stands where recultivation of grasslands is impossible or disadvantageous. The dependence of dry forage yields (y) on the N application rates (x) is expressed with sufficient precision by the quadratic equation (in kg/ha): $y=3240 + 29.878x - 0.0394x^2$. The maximal production ability is in average 8.5 t/ha of dry forage and the necessary N application rate for its reaching 380 kg/ha. The economically most favorable N application rate is in the total average 235 kg/ha, which represents 62% of the N application rate necessary to reach the maximal yield. The yield that corresponds to the economically most favorable N application rate represents 91% of the maximal yield. From comparison of increasing energy yields utilized for cattle foddering with the increased inputs of the additional energy necessary on N-fertilizers and their application, the most favorable application rate is 196 kg N/ha. The maximal yield of dry forage is reached at the concentration of 3% of N in dry matter (variable from 2.8% in years with favorable precipitation to 3.8% in drier years. The economically most favorable increase of yield per 1 kg of N application was on average 20 kg of dry forage (16-26 kg) and the recovery of the added N was 55% (48-65%) from the increased crops. The long-term N (+PK) fertilization had no explicit influence upon the amount of organic matter in the soil. The potential losses caused by leaching of NO_3-N into the depth 0.50 m, did not cross 10 kg N/ha even at the highest N application rates. The concentration of NO_3-N in lysimetric waters at the application rates of 200 kg N/ha was usually lower than in precipitation water. These results show the possibilities of intensifying the production of fodder plants on permanent grasslands by the saving of their extra production functions.

Key words: permanent grasslands, nitrogenous fertilization, N-application rates, yields, production function, performance, N-recovery, N-concentration in forage.

9-2-4

Factors Affecting the Establishment and Production of Big Trefoil on Acid, Low-Fertility Soils in New Zealand

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On undeveloped, acid (pH 5.0) soils in New Zealand, growth of the conventional legumes white clover (Trifolium repens L.), red clover (T. pratense L.) and alsike (T. hybridum L.) is limited by acidity. The objective of this research was to identify an alternative legume species better adapted to both acidity and low inputs of phosphorus (P) and to examine methods of establishment and grazing management. Big trefoil (Lotus pedunculatus Cav.) cv. Grasslands Maku and birdsfoot trefoil (L. corniculatus L.) cv. Maitland were examined.

Seed was inoculated with appropriate strains of rhizobia and sown by hand into undisturbed tussock grassland on acid soils of low P status at altitudes of 550 - 880 m above sea level. Lime and phosphorus treatments were broadcast. Herbage yields were measured by mowing or by pre-and post-grazing ground level cuts in animal grazing studies.

Big trefoil gave 2 - 3 times the yield of waite and red clover and birdsfoot trefoil. While broadcast lime increased yields of white clover (but not of big trefoil) they remained lower than those from big trefoil.

Big trefoil was responsive to P up to a rate of 60 kg P/ha while white clover reached its yield maximum at 15 kg P/ha. Lack of P response by white clover is thought to be due to high levels of exchangeable aluminium present in the soils.

Pelleting seed with lime failed to enhance nodulation of big trefoil compared to slurry-inoculation. Addition of 10% w.v. gum arabic increased storage life of rhizobia on seed.

Grazing management studies examined the effect of frequency of grazing of big trefoil in the establishment year. Deferring grazing from the time of oversowing in spring until late autumn increased the size of the rhizome system and number of potential growth sites. On established swards herbage yields were similar under close defoliation (2.5 cm) with sheep and lax (7.5 cm) defoliation by cattle.

These studies demonstrate a large potential in New Zealand for the development of native grasslands on acid soils of low P status by oversowing with big trefoil.

Key words: Lotus pedunculatus, L. corniculatus, Trifolium repens, T. pratense, acid soils, inoculation.

9-2-5 Effectiveness and Safety of Translocated Herbicides Applied to Pasture Weeds with a Rope Wick Applicator

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Applying herbicides with a rope wick applicator is a new technique that permits treatment of tall weeds without treatment to low-growing forage species. The objective of this study was to determine the effectiveness of several herbicides and to evaluate the safety to forage species. The effectiveness of 2,4-D [(2,4-dichlorophenoxy)acetic acid], dicamba (3,6-dichloro-o-anisic acid), picloram (4-amino-3,5,6-trichloropicolinic acid), and glyphosate [N-(phosphonomethyl)glycine] in water-herbicide concentrations of 2:1, 4:1, and 8:1 were evaluated on gray goldenrod (Solidago nemoralis Ait). when applied with a rope wick applicator in one and two directions on June 15 and July 17, 1979. The goldenrod was growing in a pasture containing primarily Kentucky bluegrass (Poa pratensis L.). Red clover (Trifolium pratense L.) was sown into the stand the winter after treatment to detect any residues of herbicides that might be present. Some injury to red clover occurred with picloram. Picloram, applied in two directions, killed more than 80% of the goldenrod, while the mortality of goldenrod reached 60 to 65% with the other herbicides. Early treatments and treatment in two directions were most effective. Forage grasses were unaffected by the herbicides. This method of application effectively controlled goldenrod with smaller amounts of herbicides than with conventional broadcast applications.

Key words: 2, 4-D, picloram, glyphosate, dicamba, Solidago nemoralis, rope wick.

9-3-1 Renovation of Tropical Legume-Grass Pastures in Northern Australia

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Liveweight gain of cattle on tropical legume-grass pastures is highly correlated with legume content. Legume yield decline is a major problem with 200,000 ha of Siratro (Macroptilium atropurpureum) based pastures in Northern Australia. This decline is largely associated with overgrazing. Resting for at least one year has been required to substantially improve Siratro yield and a more rapid method of restoring its yield was required.

The effect of various forms of mechanical soil disturbance on Siratro population and yields was therefore compared with pasture spelling (control) in four replicated experiments and on three commercial pastures near Mackay in coastal north-eastern Australia. The renovation treatments were cultivation with tines, deep ripper, disc narrow, disc plough and rotary hoe, with a control treatment of no cultivation at all sites. Three of the experiments contained an oversowing treatment of 2 kg ha^{-1} Siratro seed. Associated grass was Kazungula setaria (Setaria sphacelata var. sericea) at six sites and Rodd's Bay plicatulum (Paspalum plicatulum) at one site.

The main effect over all sites was for cultivation to increase the number of Siratro seedlings over the controls from 3 to 10 m^{-2} and Siratro yield from 263 to 1 289 kg ha^{-1}. Disc ploughing produced more seedlings (17 m^{-2}) and higher Siratro yields (1 439 kg ha^{-1}) than tine ripping (9 m^{-2} and 501 kg ha^{-1} respectively), the latter disturbing approximately 50 percent of the pasture surface. One advantage of disc ploughing was to substantially reduce the associated grass yield, and hence its competition in the early part of the growing season. Oversowing with 2 kg ha^{-1} Siratro seed failed to increase Siratro populations or yield. An adequate reserve of Siratro seed in the soil was found to be essential and management of pastures should aim to achieve these reserves. The renovation phase offers the opportunity for introducing newly available better adapted pasture species.

This study showed that pasture renovation using cultivation was a rapid method of restoring the legume content of Siratro based pastures. Reasons proposed for the higher Siratro yields from cultivation were increased Siratro populations, reduced soil compaction, improved soil aeration, increased mineralisation of nutrients and reduced competition from associated grasses.

Key words: renovation, tropical pastures, siratro, legume decline, soil seed reserves, oversowing.

9-3-2 Sod-Seeding Annual Legumes in Bahiagrass (*Paspalum notatum*)

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Bahiagrass is widely grown in the southern latitudes and has many attributes: starts from seed, has few disease and insect problems, tolerates heavy grazing and low soil fertility, and resists weeds. However, low quality restricts animal performance, and production is limited to 4 to 5 months in the subtropics. Poor grass quality in the summer could be improved with tropical legumes, and in winter low yield could be increased with temperate legumes. Experiments were undertaken from 1976 to 1980 to develop practices for establishing legumes in bahiagrass.

Temperate legumes (*Medicago sativa*, *Trifolium pratense*, *T. repens*), which act as winter annuals in Florida, were seeded in bahiagrass in November, and in June tropical legumes (*Aeschynomene americana*, *Alysicarpus vaginalis*, *Indigofera hirsuta*) were seeded. To control competition, the sod was treated as follows: paraquat(1,1' Dimethyl -4,4' bipyridinium ion) (0.28 kg/ha) 48 hrs before seeding with sod burned at seeding (P+B); paraquat (0.28 kg/ha); dalapon (2,2-Dichloropropionic acid)(2.49 kg/ha); and no sod treatment (check). Parameters evaluated were: seedling number; effect of herbivore pests on winter legume seedlings; legume yield and quality; and measurement of light reaching *Aeschynomene* seedlings.

Temperate seedlings in the P+B treatment averaged 131/m^2 compared with 47, 55, and 64 seedlings/m^2 in the check, paraquat, and dalapon treated grass, respectively. Depredation by the snail (*Polygyra appelna*) was primarily responsible for this difference. Field populations were 8.9 snails/m^2, and one snail per six seedlings was shown to result in 100% mortality. The P+B treatment resulted in peak soil-surface temperatures of 83C, killing 98% of the snails. Legume dry matter yield from P+B treatments (6895 kg/ha) was greater than the check (3600 kg/ha), paraquat (4790 kg/ha), or dalapon (5710 kg/ha). Because of better legume stands, crude protein and IVOMD were higher in the grass-legume mixtures in the P+B treatment (15.7% CP and 63.4% IVOMD) as compared with the check (13.5% CP and 58.6% IVOMD), paraquat (14.5% CP and 60.0% IVOMD) and dalapon (14.6% CP and 62.0% IVOMD).

Tropical legume yield was affected by herbicide treatment and was greater in the P+B (2970 kg/ha) than in the check (260 kg/ha) or paraquat (400 kg/ha), but equal to the dalapon (2690 kg/ha). Measurement of light indicated that during the first 6 weeks of legume growth, more light (23 Einsteins/day or 57% of incident light) resulted from the P+B treatment compared to the check (13 E/day or 35% incident). Protein in the grass-legume mixtures was 8.7% in the P+B treated sod as compared to the check (6.9%), paraquat (6.2%), and dalapon (11.3%) treatment.

These results imply that grass control is always important and pest control can be a factor in sod-seeded legume establishment. Two types of bahiagrass canopy competition were recognized: cover present at seeding, and cover resulting from grass growth after seeding. It is more important to remove sod before seeding temperate legumes because cool temperatures replace the function of suppression by a herbicide.

Key words: Medicago sativa, Trifolium repens, Trifolium pratense, Aeschynomene americana, Alysicarpus vaginalis, Indigofera hirsuta, sod seeding, temporary pastures.

9-3-3 Legume Establishment in Subtropical Grass Pastures with Minimum Tillage

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The establishment of adapted legumes in existing grass swards can greatly improve the productivity of pastures not fertilized with nitrogen. However, legume establishment is difficult under most conditions unless the soil is tilled to reduce grass competition and insect populations. This procedure is costly and exposes the soil to erosion hazard.

Beginning in 1974, a number of trials were conducted to develop a single or double pass technique which would control grass competition and insects at a reasonable cost and without severe soil erosion. The herbicides paraquat, glyposate, and dalapon were compared and the best results were obtained using dalapon broadcast at 4.1 kg 2,2-DPA a.i. ha^{-1} (5.6 kg of the 74% formulation ha^{-1}) as a "chemical frost" which inhibited the growth of pangolagrass (Digitaria decumbens) or kikuyu-grass (Pennisetum clandestinum) for a period of 3-4 months. A number of insecticides were also observed (no data taken) with poor results (diazinon, diazinon plus methoxychlor, and methadathion). Carbofuran and chlorpyrifos (both at 1.1 kg a.i. ha^{-1}) were compared in one experiment, and the later was highly effective in controlling armyworms (Spododoptera spp.), cutworms (Agrostis ipsilon and Peridroma saucia) and other insects which attacked legume seedlings. Its effectiveness was confirmed in subsequent experiments, and it has the additional advantage of being a relatively safe product to use.

Adapted legumes can therefore be established with reasonable assurance of success when moisture and nutrients are not limiting, using these chemicals and minimum tillage. The seeds must be brought into contact with moist soil, either by trampling by animals or through the use of sod-seeding equipment. Sod-seeding machinery may be indicated for phosphate deficient soils where band placement of fertilizer is needed for legume seedling development. In the United States, dalapon is registered for use in Gulf States and Hawaii at the rate recommended here, but registration of chlorpyrifos for pasture use has not yet been approved as of this writing.

Key words: legume establishment, subtropics, herbicide, insecticide, minimum tillage.

9-3-4 *Stylosanthes hamata* Establishment and Woody Weed Regrowth as Influenced by Seedbed Preparation

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In tropical and subtropical open woodlands of Australia beef cattle grazing native grasses increase their bodyweight mainly in the hot, wet months. When quality of the pastures declines rapidly after the hot summer months cattle generally lose weight. The introduction of a persistent legume into native pastures growing on infertile soils to improve feed quality is being investigated. One experiment established in December 1978 near Moranbah (22°S148°E) on a red earth soil following tree clearing, examined the effects of legume seeding rates (2, 10, 100 kg ha^{-1}), fertilizer treatments (nil, PKSMo, PKSMoCa) and seedbeds (untreated native grass, native grass burned, cultivated) on *Stylosanthes hamata* cv Verano establishment, native spear grass (*Heteropogon contortus*) growth and woody weeds regrowth. No grazing or defoliation was imposed. The 3^3 factorial split plot design had seedbeds as main plots and there were three replicates. Legume seedling counts were taken weekly in fixed quadrats from sowing to May 1979 when dry matter yields for legume, native grass and herbaceous weeds were assessed. The regrowth of woody weeds in each subplot was counted in February 1980 when legume numbers were also recorded.

Seedbed treatments had a significant effect on legume establishment and woody weed regrowth, cultivation giving best establishment but highest density of woody weeds. There was a marked response to fertilizer and although the highest seeding rate gave highest plant densities, the lower seeding rates produced larger plants. Cultivation eradicated spear grass with negligible regeneration in 15 months, whereas a spear grass-Verano pasture was achieved in the uncultivated plots. Fertilizer enhanced legume establishment and relatively low seeding rates were adequate. A major conclusion was that a single cultivation, although providing the best seedbed for legume establishment stimulated the regeneration of woody weed seedlings.

There are extensive areas of open woodland rangelands in northern Australia which can be improved by the introduction of a persistent legume into the native pasture. Tree clearing as shown in this experiment can induce regrowth problems (3800 woody plants ha^{-1}) and a one pass cultivation aggravates this (14 000 plants ha^{-1}). Development of similar rangelands should avoid tree clearing and cultivation. The selection of an adapted legume suitable for broadcasting directly into the undisturbed vegetation should lead to more stable rangeland developments and the approach would be more readily accepted and adopted by beef cattle producers on extensive open woodland rangelands. Several Stylosanthes species, including *S. hamata* and *S. scabra*, indigenous to South America have demonstrated their adaptation to conditions in northern Australia.

Key words: verano stylo, *Stylosanthes hamata*, *Stylosanthes scabra*, seedbeds, establishment, tree clearing, rangelands, woody weeds, spear grass, *Heteropogon contortus*.

9-4-1

New Methods for Establishing Grass in the Southern Plains

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Native and introduced grasses are difficult to establish in the Southern Great Plains. Seedling establishment is often prevented by rapid drying of the surface 2 or 3 cm of soil in which most grass seeds are planted. Three new or non-traditional methods of avoiding the problem in establishing grass were studied.

The first method was punch planting The seeds were placed in the bottom of an open hole that was much deeper than the normal planting depth; therefore, the soil around the seed remained wet longer than surface soil. The second method studied was planting germinated seeds, which emerged quickly, thus avoiding the rapid drying of the surface soil layers. The third method was transplanting live plants that were grown and transported in plastic bandoleer strips.

When the soil surface was kept wet, there was little difference in seedling emergence between punch planting and conventional planting; when conditions were dry, as is often the case in the field, substantially more plants were established by punch planting than by conventional planting. Grass seeds germinated before planting to the point at which the radicle was ready to emerge, produced significantly more seedlings than conventional planting, especially under dry conditions. Seedlings grown in the bandoleers and transplanted to the field produced very satisfactory grass stands. Ninety-five percent of large bandoleer transplants survived for 8 months in the field; however, all plants from the conventional seeding died.

Each new method for establishing grass was better than the conventional method. Planting germinated seeds may be the easiest and most economical method to use in the field. With the development of appropriate machinery, the bandoleer transplant method may become economical for grasslands. Punch planting is limited in field use by rainfall filling the open holes with soil, and by the lack of satisfactory machinery for field planting.

A significant improvement in the probability of success in grass establishment would make true range and pasture management more feasible in the Southern Plains.

Key words: grass, seed, planting, establishment, range, pasture, Southern Plains.

9-4-2

Grass Establishment: An Evaluation of Seedling Characteristics Relative to Winter Injury, Survival, and Early Growth

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Stand establishment in northern latitudes presents a challenging problem that must be conscientiously dealt with to obtain optimum response from introduced grasses. Many variables have been studied in regard to establishment, but relatively little research has been done on early seedling growth and development *per se*. Yet this is a time when plants are most vulnerable to winter injury, desiccation, competition, grazing, and other adverse impacts. Our research has sought to identify some of the critical morphological features in seedlings that can influence grass establishment. Specifically, objectives were to: (1) define and quantify relationships between morphological development and winter injury, survival, and growth; and (2) develop a management strategy for stand establishment that considers early seedling growth and development.

Research work was performed using field plantings. Three perennial forage species--crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.), pubescent wheatgrass (*Agropyron intermedium* subsp. *trichophorum* (Link) Reichb. ex Hegi), and Russian wild ryegrass (*Elymus junceus* Fisch.)--were seeded in late summer and early fall to obtain seedlings with diverse morphological characteristics. Individual seedlings that emerged were marked after reaching a winter-dormant condition or upon emerging the following spring. The number of leaves was counted and correlated with winter damage, spring and fall growth, and summer mortality.

Winter injury was inversely related with plant size in all three species and could best be expressed by a quadratic curve. As plant size increased, winter damage decreased. Spring and fall growth were directly related to both seedling size and winter injury. Greater growth and higher summer survival were found in seedlings that had more early-spring leaves, while substantially less growth and survival were observed in plants that emerged in the spring from late autumn seeding. Growth relationships were readily quantified by an exponential curve.

With respect to management applications, it is highly desirable to minimize the grazing deferment interval so that forage utilization can begin sooner. Our results show that this is best accomplished by late-summer planting to assure that seedlings reach a size of three or more leaves before winter. Such seedling development results in reduced winter injury, better summer survival, and greater growth during the following season.

Key words: grass establishment, winter injury, seedling survival, morphogenesis, planting, stand development, growth.

9-4-3 Substantiation of Technological Parameters of a Combined Aggregate for Wild Grass Strip Undersowing on Semi-Desert Pastures

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Semi-desert natural pastures are low in productivity (350 kg/ha) and poor in botanical grass stand composition. They can be improved by sowing cultivated plants (desert wheat grass, Siberian wild rye) from identical agriecological zones or the more adapted aborigines from the local flora (prostrate summer cypress, marsh bentgrass, Russian thistle and other valuable fodder plants). However, radical improvement with plow tillage is unacceptable because it causes wind erosion, kills many valuable wild plants, and new seeded grasses do not always take root. The aim was to develop technology and a combined aggregate for wild grass strip undersowing in natural grass stands of semi-desert pastures, providing increased grass yields, reducing labor and expenses and preventing wind erosion.

We have studied the technological parameters of tilled and seeded strips and determined agrotechnical and energetical indices of tools of the combined aggregate which in one pass deeply loosens the soil, carefully crushes the soil with rotary cultivators, seeds wild grass and rolls the seeded strips.

The results of investigations in 1976-1979 on black lands of Kalmytsskaya ASSR indicated that good grass stands are formed on fallow, winter rye stubble, and highly trodden pastures in tilled strips the width and depth of which are not less than 10-12 cm with interrow spacings of about 70 cm. Deeper tillage is required on compact soddy virgin soils. Siberian wheat grass, seeded in the fall of 1976, was in spring and fall of 1977 not significantly affected in height by different tillage depths ranging from 42 to 47 cm. Yield was 930 to 970 kg/ha. Height of prostrate summer cypress in the second year of life and the natural fodder yield in relation to tillage depth (5-10, 15, 20, 35-40 cm) were from 44 to 51 cm and from 4020 to 4660 kg/ha, respectively. At loosening depths of 40-60 cm, the prostrate summer cypress yield was not increased. Longevous grass stands established on virgin soddy soils with soil loosening 35-40 cm deep and 20-30 cm wide and interrow spacings of 70 cm, resulted in increased grass yields by 3 to 8 times.

In conditions of Middle Asia (Uzbekstan, Semarkandskaya region) the height of prostrate summer cypress on fallow was 2 to 2.5 times higher than plants on virgin soils and dry matter yields were 1360 and 640 kg/ha, respectively. Average yield second year of prostrate summer cypress was 1080 kg/ha, 3 times higher than natural pastures. The vest depth and width of soil loosening was 20 cm, of rotor-tilling was 10 to 12 cm, and of interrow spacings 70 cm.

The optimum technological parameters of tilled strips for improving semi-desert pastures of the main zones of the USSR are: soil loosening depths of 35 to 40 cm; loosened strip widths of 20 to 30 cm; depths and widths of rotor-tilling of 10-12 cm; and interrow spacings of 70 cm.

Key words: strip tilling, strip sowing semi-arid pastures, forage yield.

9-4-4

Growth and Development of *Poa annua* L. in Different Grass Vegetations

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Poa annua occurs in different types of grass vegetations (pastures, lawns, sport fields, etc.). In cultivated grasslands in the Netherlands, *Poa annua* is far more frequently found in pastures than in hayfields; the soil fertility in pastures is higher. In this case, the two interrelated factors that affect the growth and development of *Poa annua* are soil fertility, and the frequency and height of defoliation. In an attempt to ascertain the importance of each factor, pot trials were set up in which *Poa annua* was compared with *Lolium perenne*, the main component of cultivated grasslands in the Netherlands.

In one pot trial, small swards of *Poa annua* and *Lolium perenne* were grown at 8 levels of nitrogen and harvested every four weeks. At the first harvest *Poa annua* had higher yields than *Lolium perenne*, at the second harvest the yields of both species were the same, but at the third and the fourth harvests *Poa annua* was less productive than *Lolium perenne*. This was attributed to the mass formation of flowering culms in *Poa annua* and to the fact that after these culms had been cut off, this species recovered very slowly from basal stem buds.

In a defoliation experiment, small swards of *Poa annua* and *Lolium perenne* were cut twice a week at 1 cm and at intervals of 1,2,3 and 4 weeks at stubble heights of 2 and 6 cm. The swards were fertilized to promote maximum growth. Frequent cutting at low stubble heights resulted in higher yields for *Poa annua* than for *Lolium perenne*, but at the combination of longer cutting intervals and greater stubble heights the reverse was found. This also seemed to be due because *Poa annua* regrew very slowly after many of its flowering culms had been cut off. At frequent low cutting, *Poa annua* had formed a dense sward of many short leafy shoots. Frequent cutting inhibited stem formation and strongly stimulated tillering of *Poa annua*.

Its low growth habit and its slow recovery after many of its flowering culms have been cut off mean that *Poa annua* is a less competitive species in the taller grass crops in hayfields. In pastures, *Poa annua* occurs in large quantities in the seed bank of the upper soil layer of 0 - 5 cm (4000 seeds per m^2), whilst due to its fast relative growth rate this species can easily colonize open patches in the sward. *Poa annua* occurs in a large variety of growth stages in pastures and can be reasonably productive at successive cuts. At frequent low cutting, as in lawns, *Poa annua* forms a dense sward of short, compact, leafy shoots and behaves like a perennial species.

Key words: Poa annua, Lolium perenne, fertilization, cutting frequency, cutting height, shoot morphology.

9-5-1 Yield of Mixtures Containing Local Ecotypes or Cultivars in Response to Nitrogen Applications

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General observations on permanent grassland paddocks which were used as pastures with occasional cuts have shown that with higher intensity of management and fertilization the sward density decreases. This is especially true for swards composed of local ecotypes in comparison with those established from sown cultivars.

To investigate this problem on the research farm Rengen/Eifel, altitude 480 m, annual precipitation 810 mm, mean annual temperature 7.6°C, a trial was carried out during 1974-1980 in the form of a Latin square with 4 replications on a sward of the type Lolio-Cynosuretum, subassociation of Ranunculus bulbosus, facies of Lolium perenne. Besides the factor years with 6 levels, it contained the factor sward with levels ecotypes and cultivars and the factor nitrogen-fertilization with levels 10, 40, 70 and 100 kg N/ha per grazing. All plots received the same amount of 100 kg/ha P_2O_5 and 200 kg/ha K_2O per year. The ecotypes to be compared belonged to the above-mentioned plant association. The cultivars were part of the following mixture: Lolium perenne NFG, Barenza, Vigor with 5 kg/ha each, Festuca pratensis Cosmos 8 kg/ha, Phleum pratense Philewiola 3 kg/ha, Poa pratensis Union 3 kg/ha, Festuca rubra rubra Roland 2 kg/ha, Trifolium repens NFG-Gigant 2 kg/ha. During the vegetation periods there were 4 grazings each year.

In the first year after sowing the mixture of cultivars was superior to the mixture of ecotypes, the old natural sward, in the mean by 1,098 kg/ha DM irrespective of the rate of nitrogen applied. In the course of the trial this superiority was shown only at the nitrogen rate of 70 kg/ha per grazing with 699 kg/ha DM. All other differences between ecotypes and cultivars were not significant on the basis of $\alpha = 0.05$.

As reasons for the differences in the first year, the effects of mineralization processes following cultivation of the soil preceding the sowing may be mentioned. The observation that only at the 70 kg/ha nitrogen level are there later significant higher yields of the cultivars in comparison with the ecotypes, can be attributed to still sufficient sward densities on these plots and to the better adaption of the cultivars to higher rates of nitrogen.

Key words: ecotype-mixtures, cultivar-mixtures, Lolio-Cynosuretum, nitrogen fertilization, dry-matter yield, sward density.

9-5-2 Effects of Site Variables and Annual Top-Dressing on Forage Yields of Ozark Rangelands

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Research and management in the Missouri Ozarks have shown forage production on wooded land can be increased by eliminating woody plants to reduce competition, by artifical seeding to change composition, and by fertilizing to increase soil nutrients; however, production of forage varied drastically between different sites and declined drastically after a 2-year period of growth. These results led us to question the relative importance of site characteristics and management in controlling production. Our objectives in the present study were to determine production trends of annually top-dressed tall fescue (Festuca arundinacea Schreb.) stands on areas previously occupied by oak-hickory forests and to evaluate a number of topographic and soil characteristics which could be important in the productivity of these lands.

Plots selected on the basis of aspect, slope, and position on slope were aerially sprayed in mid-June with 2, 4, 5-T at a rate of 5.4 kilograms acid equivalent in a mixture of 32.6 liters of water and 9.5 liters of diesel oil per hectare. Plots were burned in late August, seeded with tall fescue in early September at the rate of 18 kilograms pure live seed per hectare, fertilized according to soil test immediately after seeding, and top-dressed to "soil test" annually in March for the 5-year study period with the exception of the fourth year when no fertilizer was applied.

Plots were grazed each year in November until stubble height was reduced to 7 centimeters.

Descriptive characteristics of soils included such items as percent surface rock, percent rock in the A horizon, percent rock in the B horizon.

Production data were obtained using the double-sampling method in late June and late October each year.

Mean fescue production was 3498 kilograms/hectare over the 5-year study period. Slope, surface rock, thickness of the A1 horizon, and percent clay in the B horizon were all negatively related to mean production. Slope length, thickness of the A horizon, and available soil water in the B horizon were positively related to mean production.

Top-dressing maintained high yields over the 5-year period and masked the difference normally associated with different aspects. In the year that top-dressing was not practiced, yield of tall fescue dropped 1700 kilograms per hectare, although precipitation was very near normal. Top-dressing the fifth year produced yields nearly equal to those of the first 3 years of the study. This indicates a well planned fertilizer program was, in general, more influencial than site characteristics in forage production on Ozark hill rangelands.

Key words: tall fescue, Festuca arundinacea Schreb.
fertilization.

9-5-3 Dry Matter Yields and Chemical Composition of Tropical Grasses in Panama

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In Panama, only a few pasture species have been evaluated in terms of dry matter yields and chemical composition under different cutting intervals, cutting heights and fertilizer regimes. The objectives were to determine the dry matter yields and chemical composition of the grasses Táner (Brachiaria radicans, Napper), Hemarthria (Hemarthria altissima cv. 299995 (Poir) Stapf et Hubbard), African stargrass cv. Rhodesia 171 (Cynodon plectostachyus (K. Schum) Pilg.), Nandi (Setaria sphacelata (Schumach) Stapf and Hubbard), Coast Cross Hybrid 1 (Cynodon sp.), Transvala (Digitaria sp.), Embú (Panicum maximum, Jacq.) and Ruzi (Brachiaria ruziziensis, Germain et Everard).

Cutting intervals every 3, 6 and 9 weeks were imposed on all the grasses, in a randomized block design with factorial treatments and uniform fertilization. Plots were harvested from October 1975 to October 1977.

African stargrass, Coast Cross Hybrid 1 and Transvala were cut at a height of 10 cm., while the rest of the grasses were cut at a height of 15 cm. In all cuts, green forage samples were taken in order to determine dry matter, crude protein, phosphorus, calcium and magnesium contents.

There were significant (P=.01) differences in dry matter yields and chemical composition between species, between seasons and between cutting intervals. Embu, Nandi and Ruzi produced the highest mean dry matter yields per year (9.41, 8.85 and 8.46 t/ha, respectively), and Hemarthria the lowest yield (2.73 t/ha/yr).

Dry matter yields for the 6-week and 9-week cutting intervals were similar, but both were significantly (P=.01) higher than for the 3-week cutting interval. All the species produced more than 80% of their total dry matter yield in the rainy season.

Dry matter and magnesium contents were not significantly (P=.01) different between seasons, while crude protein and phosphorus were higher (P=.01) in the rainy than in the dry season, and calcium was significantly (P=.01) higher in the dry season.

It is concluded that these species should be harvested at 3 to 6 week regrowth intervals. However, it should be added that the nutritive value tends to decrease as the cutting interval increases from 3 to 6 weeks.

Key words: Panama, tropical grasses, cutting intervals, chemical composition.

9-5-4 Regrowth of Coloniao Grass (*Panicum maximum* Jacq.) Under Different Nitrogen Levels, Frequencies, and Heights of Cuttings

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A field experiment was carried out at the "campus" of Faculdade de Ciencias Agrarias e Veterinarias - UNESP - at Jaboticabal, SP, Brasil. The main objective was to evaluate the regrowth ability of Coloniao grass (*Panicum maximum* Jacq.) under different cutting systems.

The statistical design was a randomized block with 3 replications, and the treatments were arranged in a complete factorial scheme. The treatments were two levels of nitrogen fertilizer (50 and 100 kg N/ha), two cutting intervals (28 and 42 days) and two cutting heights above ground level (15 and 30 cm).

The following parameters were analyzed: dry matter yield and its content of crude fiber and protein, number of tillers per area after each cut, regrowth ability (measured as dry matter yield, 21 days after cutting treatments) and leaf area index remaining after the harvest.

The yields were always higher in the cuts carried out at 30 cm above soil surface, no matter which intervals were adopted (1,150 and 2,223 kg/ha for 28 and 42 days interval, respectively).

The regrowth ability was higher when cuts were performed at longer intervals and at lower cutting heights (876 and 631 kg/ha at 15 and 30 cm, respectively). At 28-day intervals no differences were found.

The higher values for number of tillers per area were obtained in the lower cutting height and more frequent harvests (539 and 200 tillers/m^2 for the plants cut at 15 and 30 cm above ground, respectively).

Data of the remaining leaf area index left after the harvests showed significant differences only when cuts were more frequent. The observed values were 1.24 and 1.59 for the 15 and 30 cm cutting heights, respectively.

The leaf area index was correlated to regrowth intensity ($r=0.5370$) and to tiller density ($r=0.5876$) at 28 day cutting intervals.

Results obtained were not influenced by the nitrogen fertilizer levels.

Key words: nitrogen, cutting height, cutting interval, yield, Coloniao grass.

9-6-1 Silage Corn Cultivation on Degraded Pasture by Means of Minimum Tillage

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The purpose of this study was to investigate the possibility of silage corn cultivation by means of minimum tillage for renovating degraded pasture in Hokkaido, Japan.

Corn (Wasehomare: a leading variety for silage in Hokkaido) was planted on the experimental farm of the Obihiro University of Agriculture and Veterinary Medicine under the condition of no-, strip and conventional tillage (plant density: 75 x 25cm, fertilizer: N : P_2O_5 : K_2O = 120 : 150 : 100kg/ha, planting date: May 23, 1978, herbicides: 5% EPTC 10kg and 47.5% atrazine 2kg/ha, 4 replicates).

Dry matter yield decreased in no-tillage plot as compared to strip and conventional tillage plots, but there was no significant difference between the strip and conventional tillage plots statistically. % of vacant hills in no-tillage plot was less than strip and conventional tillage plots, though % of lodging in no-tillage plot was increased. Fresh and dry weight of weeds were decreased as the increase in tillage intensity. Comparative light intensity at the ground level was decreased in no-tillage plot owing to the growth of weeds. Soil compaction was almost similar among these treatments.

Silage corn cultivation by means of strip tillage instead of the plough-plant method was thought to be applicable for renovating the degraded pasture in Hokkaido with the use of effective herbicides. It is advantageous for saving tillage intensity and maintaining the forage yield and also it is useful for soil improvement and weed control.

Key words: silage corn, *Zea mays* L., degraded pasture, minimum tillage.

9-6-2 Increased Use of Southern Piedmont Land and Climatic Resources by Interseeding Small Grains in Dormant Coastal Bermudagrass

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A series of experiments was conducted to assess the potential of interseeding small grains by no-till methods in dormant Coastal bermudagrass (Cynodon dactylon L., Pers.) sod for forage, silage, grain or beef production. These experiments also evaluated nitrogen (N) fertilizer requirements for forage or grain.

Wheat (Triticum aestivum L.) was interseeded in Coastal bermudatrass (CBG) sod and harvested for grain or silage. Grain yields of 1695 kg/ha were obtained, but the yield of CBG was reduced 14%. Silage yields of 6.7 tons/ha resulted in a 5% reduction in CBG yield. Whether harvested for grain or silage, 90 kg N/ha/yr was required.

The N requirement for tall fescue (Festuca arundinacea Schreb.), or rye (Secale cereale L.) interseeded in dormant CBG for 90% of maximum yield was similar at 166 and 175 kg N/ha while that of rye aerially sown in soybeans at 10% leafdrop of soybeans was appreciably less at 99 kg N/ha.

In each of 5 years, rye was no-till interseeded in each of two 1.7 ha dormant CBG fields in late October or early November and compared to tall fescue or rye after soyeans. Nitrogen was applied to each field in a split application applied in mid-November and in late January. Applications totalled 100, 134, and 90 kg N ha/yr in 1972, 1973, and 1974-76, respectively. Each 1.7 ha pasture was stocked with 7 steers for 140 days from early January through late May. The steers received no supplemental feed or hay. The average quantity of dry matter (DM) available for consumption during the 140-day grazing period was 1568 kg tall fescue/ha/yr, 1001 kg CBG + rye/ha/yr, (214 kg rye/ha/yr) and 268 kg rye/ha/yr for the first 105 days followed by 780 kg tall fescue/ha/yr for the final 35 days of the rye-following-soybeans treatment. Total steer gains/ha (5-year average) were 202 kg for tall fescue, 320 kg for rye interseeded in dormant CBG for 140 day , and 257 kg for rye grazed 105 days followed by 35 days of tall fescue.

Small grains interseeded in dormant CBG sods were shown to be capable of producing 3000 to 4000 kg DM/ha/yr rye grazing, or 1695 kg wheat grain, or 6.7 tons wheat silage DM/ha, or 320 kg beef gain/ha/yr over a 140-day grazing period. This steer gain was 58% better than steer gains on tall fesc over the same 5-year period. Interseeding small grains for forage, grain, or beef production in dormant CBG can effectively increase the use of land and climatic resources as well as add flexibility to agricultural systems in the Southern Piedmont while enhancing soil and water conservation.

Key words: Coastal bermudagrass, Cynodon dactylon L. Pers., Secale cereale, beef cattle, interseeding, tall fescue, Festuca arundinacea Schreb., Triticum aestivum L.

9-6-3 Establishment of Alfalfa Cultivars with Oat and Wheat Companion Crops

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Small grains such as oats (Avena sativa L.) and less frequently wheat (Triticum aestivum L.) are used as companion crops for alfalfa (Medicago sativa L.) establishment. Small grain cultivars are often selected as companion crops according to the level of grain production and not on the basis of compatibility with legume seedlings. Our objective was to evaluate the suitability of diverse oat and wheat cultivars as companion crops for alfalfa.

In Experiment I, studies were conducted at two locations in which 'Agate' and 'Saranac' alfalfa were established with and without (check) a preplant incorporated herbicide and with 'Era' (semidwarf, late maturing) and 'Waldron' (tall, early maturing) wheat and 'Froker' (tall, late maturing) and 'Stout' (short, early maturing) oats as companion crops. Dry matter yields were measured for small grains when harvested for forage (soft dough) and grain during the establishment year and for alfalfa at 1/10 bloom in the establishment and succeeding year. To further evaluate the interaction between alfalfa cultivars and small grain crops, several alfalfa cultivars of varying winterhardiness were established with Stout oats and Era wheat (Experiment II). Oat and wheat grain yields were measured.

In Experiment I, Froker oats had the lowest and Era wheat the highest forage dry matter yields at both locations. Cultivar yields within small grain species were not significantly different. Forage yields for herbicide and check treatments were significantly lower than for small grain treatments. Weeds comprised 60% of the check plot yields, but less than 5% of the forage yields from small grain plots. The year following establishment there were no residual treatment effects on alfalfa yields at location 1. However, at location 2, yields from herbicide plots were greater than those established with a companion crop, and yields from companion crop plots harvested for forage were significantly greater than those harvested for grain. A significant alfalfa cultivar x small grain cultivar interaction occurred. Saranac alfalfa had greater dry matter yields when established with Froker oats than with Stout oats or Waldron wheat. Agate alfalfa yields were greatest when established with Waldron wheat.

In Experiment II, grain yields were greatest when oats and wheat were grown with 'Ramsey' alfalfa. Oats grown with '520' alfalfa had a significantly lower yield than when grown with Ramsey, while wheat yield was significantly lower with 'Weevlchek,' 'WL 318' and 'DuPuits.'

Our results indicate that wheat and oat cultivars may be selected to provide high forage yields. Establishment method may influence subsequent year alfalfa yields. Negative interactions of alfalfa cultivars with small grain cultivars in some environments suggest that some type of interference may occur. When seeding alfalfa with a small grain companion crop, it may be necessary to select small grain cultivars for broad-based compatibility with alfalfa cultivars.

Key words: Medicago sativa L. establishment, Avena sativa L. and Triticum aestivum L. companion crops, Competition.

9-6-4 Hydration/Dehydration as a Presowing Seed Treatment: Physiology and Application

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Presowing hydration/dehydration treatments, in which seeds are partially hydrated and then dried back to their original weight before sowing, have been claimed to result in earlier and more synchronous germination and seedling emergence, to broaden the range of conditions under which germination will occur, to enhance seedling 'vigour', and to 'harden' seedlings to environmental stress. Despite these putative advantages, seed pretreatment has not become part of agricultural practice in Australia. To understand the reasons for this lack of application we have assessed the physiological benefits and problems of hydration/dehydration treatments as they apply to pasture grasses, in particular to annual ryegrass (Lolium rigidum Gaudin).

We found that pretreatment increased the speed of germination because the embryos of pretreated seeds w. in a more advanced developmental stage at sowing than were those of control seeds. Furthermore, the germinability of seeds was increased if hydration/dehydration coincided with exposure to dormancy breaking conditions, but we found no evidence to support the other claims made in favour of seed pretreatment.

Major problems in pretreating large quantities of pasture grasses are not anticipated, but because the benefits of pretreatment are lost after exposure of seeds to high temperatures or to very dry conditions, the storage of pretreated seeds may be a problem. In addition the unfavourable response of pretreated seeds to high temperatures may preclude their use in some places. Nevertheless, pretreatment could be a useful practice where species that germinate slowly are to be established in cool environments that dry rapidly after rain. For example, establishment of annual ryegrass seedlings was increased from 20% to 77% by use of pretreated seeds in conditions chosen to simulate those likely to prevail during the establishment of surface-sown seeds in winter-rainfall regions of Australia.

Key words: ryegrass, Lolium perenne, Lolium rigidum, Phalaris aquatica, presowing seed treatment, seed germination, surface-sowing, pasture establishment.

9-7-1 Maximum Production from Irrigated Rhodes Grass and Green Panic in a Mediterranean Environment

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Aspects of the production potential of Rhodes grass (Chloris gayana Kunth) and green panic (Panicum maximum var. trichoglume) as roughage for high-grade dairy cattle when land and water resources are limited are described. Results from some 10 years of research are highlighted.

The height of the canopy to which grasses should be allowed to regrow for maximum production is above the height which can be utilized efficiently when harvested in situ by cattle. Mechanical harvesting and indoor feeding provided 20-25% more digestible dry matter per unit area of land (with a parallel increase in water use efficiency), compared with strip grazing, almost without affecting the level of milk production. The efficiency of a single application of N fertilizer after cutting sharply decreased when the interval between irrigations was long, apparently due to leaching below the relatively shallow root system. Frequent irrigation and nitrogen application resulted in optimum uptake of nitrogen and high sustained yields during the season and over the years. Sewage effluent (containing about 50 ppm N) is an excellent source of water and of plant nutrients.

The rate of initial regrowth after cutting was inversely related to the length of the period before cutting, particularly during stem elongation and flowering, which is promoted by high temperature. Relatively long cutting intervals in spring are permissible and result in high dry-matter yields of relatively high digestibility. During summer, shorter cutting intervals are necessary in order to obtain comparable yields of digestible nutrients. Yields of 25 and 35 t dw ha^{-1} $season^{-1}$ of Rhodes grass and green panic, respectively, were recorded from commercial fields. In vitro digestibility of green panic was approximately 10 percent higher than of Rhodes grass.

Key words: Rhodes grass, Chloris gayana Kunth, green panic, Panicum maximum var. trichoglume, fertilization, cutting, digestibility, dairy cattle.

9-7-2 Growth and Productivity of Italian Ryegrass Under Mediterranean Irrigated Conditions in Comparison with Berseem

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The introduction of Italian ryegrass (Lolium multiflorum L., cv Avance) as a complement to berseen (Trifolium alexandrium, local ecotype) in the irrigated area of the Gharb (North of Morocco) is presented. For two sowing dates we established (1) the weekly growth curves of the plant and (2) the effect of two cutting systems on dry matter production and chemical composition.

Establishing growth curves, 3 years, and cutting system, 1 year, was carried out on a heavy soil (60% clay) and during concentrated rainfall between October and April (about 700mm/year). Two 70mm/ha irrigations were applied, the first at the sowing date in September and the second in May. Because of the rainfall irregularity another irrigation may have been applied in winter. Soil was fertilized with 150 and 100kg/ha of P_2O_5 and K_2O, respectively. Nitrogen application amounted to 300kg N/ha and was distributed as 60kg/ha at the tillering stage and 60kg N/ha/cut for 4 cuts.

Growth curves establishment: The experimental design included blocks with 4 replications being used. Each block was divided into 4 pieces corresponding to the 4 cycles studied. A cycle represented a growth period from the sowing date to the first cut or between two successive cuts. The S-curve of every cycle was built from 9 weekly measurements of dry matter production from random samples of $3x2m^2$. Chemical composition of dry samples was determined.

Cutting system study: Two frequencies of cutting,(a high frequency, 4-5 week interval, and a low frequency, 6-7 week interval) and four final harvesting dates of cutting in winter (D_1=22 Feb., D_2=8 March, D_3=22 March, D_4=5 April) were tested in 5 blocks. Each block was divided into 8 pieces of $15x10m^2$ corresponding to 8 treatments totally randomized. A treatment was rhythm of cutting x last harvest date of cutting. The dry matter yield was measured in the central part of the piece, using $6x4m^2$. Chemical composition was analysed.

The September sowing resulted in high production and high nutritive value, up to 18 tons DM/ha and 13,000 FU/ha and 2,100kg DCP/ha. The growth rate remained high and varied from 70kg DM/ha/day in the winter vegetative growth to 180kg DM/ha/day in the spring reproductive period. The early sowing (September 22) showed a 40% superiority over the later sowing (November 24th). High frequency of cutting favored the yield in DCP while low frequency favored yield in DM and FU. A last cutting date earlier in March allowed an important fodder reserve for storage as silage or hay making. Under the North Africa climate, Italian ryegrass shows a long pre-earing period, which makes this plant particularly interesting as a green fodder. The ryegrass-berseem comparison showed a slightly higher yield for the graminae, the two species remaining very productive. Ryegrass was more resistant to submersion than berseem and could be preserved easier.

Key words: Lolium multiflorum, Trifolium alexandrium, sowing date, cutting date, yield.

9-7-3 Water Regime in Flooded Grass Stands

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To study water regime of grass stands, dynamics of water usage and other elements of the water balance, lysimetric equipment was used to allow observation throughout the year. In medium loam soil monoliths the ground water level was maintained at 150 to 200 cm. The sown sward consisted of bromegrass, meadow fescue and timothy. Under optimal nutrition levels the time of irrigation was set as moisture deficit, equal to 5 cm. Coefficient of representivity of field and lysimetric conditions amounted to 1.06.

Average, for 5 years, moisture requirements of highly productive (9-10 t of dry matter/ha) grass stands, under high rates of fertilization and 5-fold cutting on alluvium soil, amounted to 541.6 mm, rising in dry vegetative periods to 554.6 mm and decreasing in moist and cold periods to 455.4 mm. When ground water was nearer the surface than 1.5 m water usage dropped by 2 to 14%. Maximum water consumption per year was equal to 636.7 mm; for vegetative period, 526.6 mm; for regrowth, 210.1 mm; for decade, 91.0 mm; for day and night, 9.1 mm; and for hour, 0.38 mm. Water usage during periods of sward regrowth proceeded irregularly even under irrigation. There were two maxima, the first during the spring regrowth and the second coinciding with the third and fourth regrowths. [illegible] moisture requirements coincided with tillering and formation [illegible] new growth buds.

Soil moisture reserves, determined with the neutron moisture meter within the zone of soil aeration, were discharged by evaporation at higher rates in plots with deep ground water. The most active evaporation was from the 0-60 cm layer with average moisture levels (19-20% losses).

Of the total water consumption by the meadow grass stands, ground water was essential, affected by depth of their layers and averaged from 34 to 44%. Under irrigation, the ascending moisture flow decreased. Maximum of this process was typical for dry vegetative periods in the unirrigated plots with depth of ground water 1.5 m and amounted to 227.4 mm: for year, 256.8 mm; for regrowth period, 78.6 mm; for decade, 37.2 mm; for day and night, 4.2 mm; and for hour, 0.18 mm. Distillation of ground moisture progressed in cold winter with little snow at rates up to 26.4 mm.

On open-textured soils, with uniform density (2.68-2.73 g/cm^3) and high porosity (49-54%), essential filtration of precipitation into ground water took place, especially to 1.5 m depth. Even in dry vegetative periods, infiltration of irrigated water and precipitations was 91.6 mm, increasing in moist periods to 365.8 mm which greatly exceeded the ascending flow of moisture. Intensity of the process in spring can be 7.7 mm/hr. Precipitation was infiltrated by 1.5-3 times less to the 2 m depth. In irrigated plots, filtration ability of the soil increased and water permeability intensified as soil temperature rose.

Key words: water, use, evaporation, filtration, temperature, irrigation, water balance.

9-7-4 Effective Sprinkling Irrigation of Forage Plants Under Different Site Conditions in the German Democratic Republic (GDR)

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Stability and continuity of forage production are primarily dependent upon the actual water supply and the level and distribution of nitrogen applications. Under the site and climatic conditions in the GDR, almost in any year there are certain spells when the natural water supply does not satisfy the water needs of the forage plants, this leading to severe yield loss unless sprinkling irrigation is practiced.
As sprinkling irrigation is very costly and water resources are limited, we have to make full use of all potentialities for achieving high yields and yield increments while keeping the water input at a minimum, i.e. for reaching a high overall efficiency of the supplemental water applied.
The effect of nitrogen fertilization and sprinkling on the yield level, continuity of production, and quality of multi-cut forage plants under different site conditions was therefore examined in experiments.
On all sites under review sprinkling irrigation gave significant increase of forage yields, yield increments decreasing with rising soil quality - from sand to loess. With regard to field grasses (Lolium multiflorum, Dactylis glomerata) the soil-borne yield differences between diluvial and loess sites were offset.
Italian ryegrass (L. multiflorum) proved to be the most efficient field forage plant (17 t DM/ha) under sprinkling while red clover/grass mixtures ranked second. Water utilization by forage plants improved as the need of sprinkling increased (due to soil or climatic conditions). Yield increment was 30 - 40 % (productive values >20 kg DM/mm sprinkling water) on the diluvial sites (sandy and loamy soils) and 18 - 21 % on loess.
Energy concentration, dry matter and crude protein contents as parameters of forage quality declined under sprinkling, but the crude fibre content increased slightly, the degrees of variation differing between forage plant species and between sites.
The significant results obtained were immediately made available to the cooperative farms and State farms for crop production in the GDR. They now serve as the basis for selecting those forage plants that on the different sites would give maximum and most reliable crop yields under sprinkling irrigation. Recommendations for cropping technology are given as well.

Key words: sprinkling irrigation, Lolium multiflorum, yield level, forage quality, forage quantity, perennial field forage plants.

9-8-1 Minimizing Disease Losses in Forage Crops Through Management

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Diseases cause major losses in yield, quality, and stand life of forage crops. Strategies that are used to minimize such losses include the use of resistant varieties and crop management practices that directly or indirectly affect diseases. Because of the perennial nature of both the crops and the diseases, there are many opportunities to implement management strategies to reduce diseases. Implementation begins prior to the planting of the forage crop, through the actual planting, and on through the production years. Insect control, weed control, and fertility maintenance are examples of crop management that also serve to minimize forage-crop losses to disease. Certain crop management strategies, such as varietal selection, seedbed preparation, and seeding rate, are one-time opportunities, and if they are not applied at the appropriate time, disease losses may occur. Other management practices such as fertilization and insect control are recurrent. Failure to maintain sound management practices, even for a short period, may result in severe losses, because managing forage crop diseases is basically therapeutic not eradicative. Many diseases are chronic in forage crops, taking a small toll over several years. It is the rate of disease development that management affects. The future will bring an intensification of existing disease management strategies because of increasing economic and environmental limitations. Our present system of managing forage crop diseases is effective, economical, and causes minimal disturbance to the environment, but it can be improved. Research into pathogen biology and disease development must be done before models for forage crop diseases can be developed and integrated into master models of crop production.

Key words: disease management, crop management, disease-stress interaction.

9-8-2

Improvement of Yield and Persistence of Italian Ryegrass (*Lolium multiflorum*) through Pest Control

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Our objectives were to examine (i) whether the increases in the yield and persistence of Italian ryegrass varieties following frequent pesticide application were related to a reduction in frit-fly larval populations and if so (ii) whether the use of a non-persistent pesticide would be a feasible method of reducing such damage.

In two field experiments, the yield and persistence of normally short-lived Italian ryegrasses (*Lolium multiflorum* L.) were greatly increased by the application of large and frequent doses of the potent insecticide phorate. Much of the damage was attributed to stem-boring dipterans of the frit-fly complex (e.g. *Oscinella frit*).

In one experiment, small plots of 23 varieties of Italian ryegrass were either treated with phorate every six weeks or left untreated. Varietal differences in larval numbers and yield in response to pesticide use were compared. In a second experiment, chlorpyrifos was applied on three occasions only each year to coincide approximately with the oviposition periods of frit-fly.

In the first experiment, larval numbers varied greatly between varieties but there was a positive correlation between larval numbers and tiller density. Larval numbers were related to yield increase following pesticide application in the first year only, but there were large differences between varieties in their response to pesticide treatment in all four years. At the end of the third year of the experiment, many plants on untreated plots had died, but plants on treated plots in general remained vigorous.

In the second experiment, chlorpyrifos treatment was not as effective as phorate but improved yields of the three varieties tested over a three year period by an average 25% or 2.7 t/ha/year.

It is concluded that there are large differences between varieties of Italian ryegrass in their susceptibility to frit-fly which appear to be linked to yield response to pesticide treatment and sward longevity. This suggests that there are possibilities of breeding specifically for frit-resistance to increase yield and improve persistence; in the interim it may be feasible to use infrequent doses of non-persistent pesticides to enhance yield and persistence.

Key words: Italian ryegrass (*Lolium multiflorum* L.), yield persistence, pest control, frit-fly (*Oscinella frit*).

9-8-3 Alfalfa Integrated Pest Management in Kentucky

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The Kentucky alfalfa integrated pest management program (IPM) is a multi-disciplinary program organized to insure that the cooperating farmers receive the maximum amount of information necessary to make timely economic and environmentally sound pest management decisions.

Participating farmers organize county level non-profit corporations that hire young people as "scouts" to examine fields for pest problems. The farmers assess themselves an acreage fee to provide funds for the program.

"Scouts" are trained by University of Kentucky cooperative extension service faculty to properly identify and report insect, weed and disease problems. Fields are scouted once a week throughout the growing season. After each field visit the farmer receives a written report detailing the pest situation in that field. The county extension agent and/or IPM supervisor also receives a copy of the report. If an economically important pest outbreak is imminent, the farmer is alerted by these personnel and a management recommendation is made. The farmer makes the final decision on implementation of these recommendations.

The alfalfa weevil and the potato leafhopper, the major insect pests, are monitored by IPM scouts using a sequential sampling method. Economic thresholds for these insects have been developed that take into consideration climatic conditions, parasites and predator populations as well as cultural practices. Farmers using the IPM program have maintained high production levels while reducing pesticide usage.

Weed and disease problems are also monitored. Herbicide controls are recommended for winter annual weeds. Cultural practices and varietal selections are used to combat disease problems.

The alfalfa IPM program also provides a soil test sampling service. Information on pest problems, varieties, cultural practices, and pesticide and fertilizer usage is computerized and used to formulate seasonal summaries for farmers and county extension personnel.

The alfalfa IPM program was initiated in 1975 in one county and is currently active in seventeen counties representing 835 ha. The pest sampling methods, economic thresholds and management techniques utilized in the program have been developed and adapted from state and regional research programs. The federal extension service has also provided funds to help defray organizational expenses for first year projects.

Key words: alfalfa, alfalfa weevil, potato leafhopped, integrated pest management.

9-8-4 Ladino Clover Persistence as Affected by Physical Management and Use of Pesticides

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Stand persistence is a major weakness of the widely used ladino clovers (Trifolium repens L.) in the United States. The objectives of these studies were to determine the influence of physical management practices and selected pesticides on longevity of ladino clover stands. Ladino grown alone and in mixture with tall fescue (Festuca arundinacea Schreb.) was subjected to varying physical management regimes (clipping, grass density and spacing) and insecticide and fungicide applications in two tests for 5 to 6 years. By the fall of the third year, the percent clover present (average of two tests) in the ladino clover-tall fescue untreated check, the fungicide (F), insecticide (I), and F+I treatments was 12, 34, 50 and 74%, respectively. These studies showed that physical management, per se, although important in the short run will not provide long-lived ladino clover stands, and that an entomological-pathological complex was large, responsible for the loss of stand and low productivity after the first two years.

Key words: ladino clover persistence, Trifolium repens L., pesticides on clover.

9-8-5 Control of Anthracnose of the Tropical Forage Legume *Stylosanthes capitata* by Burning

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Although the value of burning in improving forage quality and productivity is well known, there are few reports on effects of fire on diseases of pasture plants. Burning is a broad-spectrum control against fungi, reducing above-ground pathogenic inoculum.

Stylosanthes capitata, a woody perennial legume, is well-adapted to acid infertile soils, regenerates after burning and has great forage potential. In Brazil, however, many ecotypes are susceptible to anthracnose, a damaging forage disease. Disease build-up in susceptible perennials is inevitable when inoculum accumulates in foliage. Many disease control measures are impractical and selection and breeding for resistance may take years. The effect of burning on anthracnose of *S. capitata* was therefore evaluated as a temporary control measure.

At the CIAT Research Station, Carimagua, Colombia, severely anthracnosed stands of *S. capitata* CIAT 1097 were cut and burnt in April 1979. Cut unburnt plots were used as controls. Dry weight and anthracnose lesion number and size were recorded each month from five random 1600 cm^2 samples per treatment. Half of each plot was cut and burnt again in April 1980 and the same measurements were made.

By August 1979, four months after burning, burnt plots out-yielded unburnt plots. One year after burning, burnt plots had 60% less anthracnose than unburnt plots. Soil nitrogen content increased after burning and the nitrogen content of regrowth from burnt plots was higher than that from unburnt plots.

By November, 1980, plots burnt in April 1979 and those burnt in both April 1979 and 1980 had 71.5% and 75.2% less anthracnose, respectively, than unburnt plots. Regrowth from twice burnt plots was, however, less than that from once burnt plots but not significantly so.

Burning is therefore proving a potentially successful temporary control measure of anthracnose of *S. capitata*. Results suggest that biennial burning is of more value than annual burning for the particular forage-disease combination.

Key words: anthracnose, tropical forage legume, *Stylosanthes capitata*, burning.

9-9-1 Potential Grass Production in Ireland

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Variation in weather geographically and between years can have a significant impact on intensive animal production systems dependent on grass as feed. This work was undertaken to quantify the effect of weather variations on grass production. The first objective was to relate grass growth quantitatively to radiation and temperature. The relationships are obscured by large changes in sward growth potential within the season which are related to changes in the physiological status of the crop. Therefore, it was necessary to quantify this physiological effect.

Production data were drawn from production experiments and weather data were drawn from the published records of the national meteorological network.

A model is presented which relates grass accumulation to radiation received and to the efficiency of radiation use. The temperature effect is incorporated in the model through the measured effect of temperature on the efficiency of radiation use. A term is included in the model to represent the physiological factor.

It is suggested that the physiological factor is responsible for a 60% decline in production potential in June of each year and that this lower production potential persists until late December. Average annual production potential is estimated to be 12.5 tonnes/ha. Regional and year-to-year variation can cause this total to rise or fall by 13% and 15% respectively.

Key words: grass, radiation, temperature, seasonal growth, potential production, regression.

9-9-2 Annual and Seasonal Productivity of Permanent and Short-Term Pastures Based on Different Combinations of Species and Cultivars

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Considerable research information is available on the performance of species and cultivars grown alone or in simple mixtures but much less data has been obtained on the more complex mixtures which are generally sown on farms. Further, although New Zealand grassland is still largely based on permanent pastures, there is little doubt that various combinations of shorter-lived species can provide greater annual yields of dry matter. The advent of improved direct drilling techniques should reduce the cost of regular renovation of these shorter term pastures which may then be able to demonstrate real and sustainable economic increases in grassland productivity. In order to test this hypothesis and also to compare a range of permanent pasture options a long term grazing trial was established in early 1977 on a high fertility soil at Palmerston North. During the first two years the highest annual yield (almost 16,000 kg/ha) was obtained from a medium term pasture based on Matua prairie grass, Manawa and G4708 hybrid ryegrasses and Pitau white clover and Pawera red clover. This mixture outyielded a permanent pasture based on Nui perennial ryegrass, G4708, Pitau, Pawera and G16 cocksfoot by 16% over the two years. The Nui pasture was little different from another permanent sward based on the older cultivars Ruanui perennial ryegrass, Manawa, Huia white clover, Hamua red clover and Apanui cocksfoot in the first year; but, it was 18% superior in the second year. This change in relative productivity was mainly the result of the outstanding growth of Manawa in the first year which was not sustained in the second year of the trial. However, both these swards substantially outyielded an ultra simple mixture of Nui and G18 white clover with red clover being the main contributor to the difference. Another interesting mixture has been one which was sown with 12 species and cultivars of various grass, legumes and herbs. The sward has become dominated by chicory which contributed nearly 2/3 of the annual yield in the second year. In some treatments during the third and fourth years, the growth of red clover has declined markedly while cocksfoot is more prominent particularly where the ryegrass component, e.g. Ruanui, has weakened. On the other hand ryegrass vigour in the simple Nui/G18 mixture is now superior to the other permanent pastures apparently as a result of severe competition from red clover experiences in the more complex mixtures during the first two years of the trial.

Key words: mixed species, productivity, permanent pastures, short-term pastures.

9-9-3

Seasonal Composition, Yield and Quality of Perennial Pastures, and the Autumn Feed Shortage, in an Australian Warm Temperate Climate

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Perennial pastures in Australian warm temperate (Cf) and irrigated Mediterranean (Cs) regions are dominated by Paspalum dilatatum or Pennisetum clandestinum in summer and by Lolium and Trifolium spp. in winter and spring. There is always a shortage of digestible dry matter in autumn (March, April).

Experiments at Camden, Australia (lat. 34°S) since 1972 have aimed to describe and improve the summer productivity of pastures currently used by farmers, and to overcome the autumn feed shortage. We aimed to (i) select higher-yielding perennial grasses, (ii) advantageously manipulate species composition by sod-sowing, herbicides or growth substances and (iii) evaluate forages as standover feeds for use in autumn.

Kikuyu (Pennisetum clandestinum), bermudagrass (Cynodon dactylon) and common paspalum (Paspalum dilatatum) were grown in metal trays to establish potential dry matter productivity and trends in digestibility when cut every six weeks through an eight month growing season. Above-ground dry matter yields of kikuyu, bermudagrass and paspalum were 17.6, 13 and 11 tonne ha^{-1} and digestible dry matter yields were 8.6, 7.8 and 6.8 tonne ha^{-1}. In a second experiment, the same grasses were grown in the field and oversown, using a triple disc sod-seeder, with lucerne (Medicago sativa). Kikuyu was again superior, particularly in autumn, in dry matter production, competitiveness, digestibility (except leaf in early summer) and mineral content (except calcium). Lucerne yields in the second year were 11-16 tonne per ha, depending on companion grass, with high mineral concentrations (4.3% nitrogen, 1.5% calcium).

A third experiment, sampling commercially-grazed pastures before and after grazing, confirmed the higher productivity of kikuyu, which yielded 19.7 tonne ha^{-1}. It also showed that the autumn feed shortage resulted in low daily animal intake of 8.2 kg dry matter cow^{-1} day^{-1}.

The autumn feed shortage was partially overcome by changing the composition of perennial pasture through sod-sowing of oats, nitrogenous fertilizer or application of herbicide in early autumn. Field-applied growth substances (GA_3) did not change pasture composition or increase autumn productivity. Alternatively, summer forages may be grown for standover autumn feed. Standover feed from a range of tropical tallgrasses (Zea mays, Pennisetum americanum, P. americanum x P. purpureum, Sorghum spp.) and a legume (pigeon pea, Cajanus cajan) showed the tropical tallgrasses were of poor quality but pigeon pea was satisfactory. However, both grasses and legumes required high agronomic inputs.

Key words: Paspalum dilatatum, Pennisetum clandestinum, Medicago sativa, Cajanus cajan, dogestob;e dry matter, sod-seeding, standover feed.

9-9-4 Stockpiling of Cool-Season Grasses in Fall

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The practice of accumulating growth of cool-season grasses in the late summer and early fall for subsequent grazing in late fall and winter, known as stockpiling, has been widely accepted by beef cow-calf producers in the grassland transition zone of the United States. The objectives of our study were to determine the growth characteristics of cool-season grasses in the fall under N fertilization and investigate utilization of stockpiled forages.

Tall fescue (Festuca arundinacea Schreb.) has many attributes which make it highly suited to stockpiling. On Maury silt loams, 'Kentucky 31' tall fescue accumulated 6,500 kg/ha of dry matter from 16 August 1979 to 12 December 1979 with N at 100 kg/ha. During the same time, 'Boone' orchardgrass (Dactylis glomerata L.) accumulated 4,300 kg/ha and 'Kenblue' Kentucky bluegrass (Poa pratensis L.), 2,200 kg/ha. During the first month of stockpiling (mid-August to mid-September) orchardgrass outgrew tall fescue and Kentucky bluegrass with mean crop growth rates of 77, 65, and 43 kg/ha/day, respectively, but in the second month, with the onset of cooler weather, tall fescue accumulated dry matter at the rate of 84 kg/ha/day while orchardgrass and bluegrass grew at 47 and 41 kg/ha/day, respectively. In the third month (mid-October to mid-November) tall fescue grew at twice the rate (33 kg/ha/day) of the other two grasses. Yield increases in stockpiles achieved with N fertilization were mainly attributable to increased tiller dry weights and to a lesser extent, increased tiller populations.

Water soluble carbohydrates (WSC) in stockpiled tall fescue increased with rate of N fertilizer and accounted for 19% of dry matter in mid-November. Silage made from tall fescue at this time (N=100 kg/ha) had a pH of 4.4 and lactic acid accounted for 2.5% of silage dry matter. Conversion of tall fescue stockpiles into silage in late fall seems to be a feasible method of utilization in regions where severe weather impairs their utilization or accelerates their deterioration.

Key words: tall fescue (Festuca arundinacea Schreb.), orchardgrass (Dactylis glomerata L.), Kentucky bluegrass (Poa pratensis L.), nitrogen, silage.

9-9-5

Changes in Quality and Composition of Alfalfa During Autumn

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Autumn harvest of alfalfa (*Medicago sativa* L.) offers the potential for obtaining additional forage production during a particular season. Little is known about the nature of the quality or the changes in the chemical composition of this forage. The objective of this research was to examine changes in chemical composition, dry matter intake (DMI), and apparent digestibility of alfalfa during autumn in Wisconsin.

An established stand of "Vernal" alfalfa, early to mid bud, was harvested using a flail harvester on 5 and 20 October and 5 and 18 November, 1979. The forage was dried at 55 C for 72 to 96 hours in burlap bags. A total collection digestion trial was conducted utilizing four castrated Saanen goats. Apparent dry matter digestibility and dry matter intake (DMI) were determined for each forage. Each sample was analyzed for cell wall constituents (CWC), nitrogen (N), total nonstructural carbohydrates (TNC), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

The concentrations of neutral detergent fiber (NDF) and acid detergent fiber (ADF) in the forage declined by 5.4% and 5.8%, respectively, between 5 October and 5 November while the cellulose concentration decreased 6.7% during the same period. The reduction in the concentration of CWC probably represents a dilutive response to the 79.6% increase in total nonstructural carbohydrates (TNC) between 5 October and 5 November. Cellulose, ADF, and NDF concentrations increased significantly between 5 and 20 November.

A 4.8% increase in *in vitro* dry matter disappearance (IVDMD) accompanied the initial increase in TNC, followed by a 4.2% reduction between 5 and 18 November. Total nitrogen concentration averaged 4.0%, 3.7%, 3.3%, and 3.1% of dry matter at each successive harvest date, respectively.

Dry matter intake ($g/kg^{0.75}$) increased 9.2% from 5 October to 5 November and then decreased 4.7% by 18 November. Digestible dry matter intake (DDMI) increased from 51.7 $g/kg^{0.75}$ on 5 October to a high of 56.1 $g/kg^{0.75}$ on 5 November and then decreased slightly by the last harvest date. Decreases of 5.8% and 8.2% in the apparent digestibilities of NDF and ADF respectively, occurred between 5 October and 5 November. This reduction in fiber digestibility may reflect an increase in rate of passage resulting from the increase in DMI. The apparent digestibility of cellulose also decreased 5.0% during this period. The apparent digestibility of cellulose, ADF, and NDF increased between 5 and 20 November. Apparent digestibility of nitrogen decreased slightly during autumn. These data indicate that the feeding value of alfalfa, as well as the ensiling potential, may increase initially during autumn due to increasing TNC concentrations during that period.

Key words: alfalfa, *Medicago sativa* L., digestibility, dry matter intake, forage quality, nutritive value.

9-10-1

Grass Growth and Herbage Quality at Northern Latitudes

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At the northern frontier of agriculture the most effective production of forage protein can be reached by intensive grass farming. In Finland, which is situated between the 60th and 70th latitudes, grass can produce more protein than the other agricultural crops and the most winterhardy grass species are successfully grown almost all over the country. During a decade, grass area grown for high protein silage has rapidly increased and is now about a fourth of the total grass area grown in rotation with cereals.

Because feeding of cattle is mainly based on grass its nutrient content and quality are especially important. The quality of grass yield is largely determined by the methods of cultivation as well as growth conditions: (1) time of cutting, (2) amount of nutrients in the soil and fertilization, (3) grass species, and (4) temperature and precipitation, moisture conditions of the soil, irrigation.

The effect of the time of cutting on amount and quality of yields of timothy, meadow fescue, cocksfoot and perennial ryegrass were studied at nitrogen fertilization rates of 150 and 300 kg/ha a year, shared equally between spring, summer and autumn growths. The experiments were conducted at four institutes and experimental station in 1973, 1974 and 1975.

The dry matter yield of the spring growth increased by 150 to 200 kg/ha/day, and under more favorable conditions by over 300 kg/ha. When N was applied at the rate of 100 kg/ha in spring (yearly rate 300 kg/ha) the crude protein content decreased almost linearly from 20% at the beginning of tillering to 10% at the stage when all the panicles had emerged from the sheath. When the N fertilization level was 50 kg/ha the crude protein contents were 3 to 4% units lower. The daily decrease in the crude protein content averaged 0.5% units.

The crude protein increased from 20 to 32% of dry matter, by 0.5% units a day. Dry matter digestibility decreased from 80% to 60-65%, or by 0.8-1.0% units a day. An increase in the application of N did not affect digestibility. The content of K, P, Ca and Mg decreased with increasing age of the grass.

The later the spring cut was performed during the period of strong growth, the poorer was the recovery and growth of the grass after cutting. Recovery was weakest when the grass was cut at the normal time for silage when the first panicles began to emerge from the sheaths. The earlier the spring cut, the more panicles were formed in the aftermath. Depending on the time of cutting of the spring growth, the crude protein content of aftermath grass of the same age varied by over 10% units, the crude fiber content by 8% units and dry matter digestibility by 10% units.

In autumn, changes in the quality of the growth were slow; at the lower level of fertilization a deficiency of N was evident.

Key words: cutting time, nitrogen fertilization, regrowth, yield, composition.

9-10-2 Production Response of Russian Wildrye (*Elymus junceus* Fisch.) to Fertilizer and Clipping

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Experiments were conducted to obtain information on nitrogen (N) fertilization of long-term Russian wildrye (RWR) (*Elymus junceus* Fisch.) pasture and the effect of simulated spring grazing on the quantity of forage available for fall use. A portion of a RWR stand which had been fertilized with 45 kg N/ha and grazed annually for 10 years at Mandan, North Dakota, was divided into two experiments in 1978. The first evaluated effects from all combinations of 0, 45, 90, 135, 180, and 225 kg N/ha; 0, 45, and 90 kg phosphorus (P)/ha; and 0 and 135 kg potassium (K)/ha on dry matter (DM) yields, whereas the second compared 10 clipping treatments ranging from biweekly intervals to fall (clipping after frost) harvests. Precipitation was above average in 1978, below average in 1979, and severe drought through June of 1980 followed by above average precipitation during July and August 1980. Yield was increased with each increment of fertilizer N up to 180 kg/ha in 1978 and 1979. Yields ranged from 3220 to 6860 kg/ha in 1978 and 1040 to 5690 kg/ha in 1979. Yield on 17 July 1980, was lower ($P < .05$) for 0 N than 90 N or more, but since the yield was only 110 kg/ha, treatment differences were of little practical value. After drought recovery, a 25 Sept. 1980 harvest produced yields ranging from 240 to 2150 kg/ha for 0 N through 225 N with each increment of N significantly increasing yield. Neither P nor K fertilization influenced yields. Biweekly clipping of RWR reduced yield each year and resulted in thin, weed-infested stands. Early July clipping produced maximum yields in 1978 and 1979 but not in 1980 when drought resulted in poor spring and summer growth. Light spring grazing, simulated by a harvest at a 13-cm stubble height on 5 June 1978, produced 1430 kg/ha DM at the fall harvest compared with a previously unharvested fall yield of 3020 kg/ha. Results from these studies indicate 45 N rates are insufficient to maintain optimum DM yield of RWR, especially during dry years. If fall grazing is the primary intended use for RWR, limited spring utilization may greatly reduce forage available for fall grazing even though total production may be increased. Biweekly harvests reduced overall yield and vigor of RWR.

Key words: Russian wildrye, *Elymus junceus* Fisch., fertilizer, clipping interval, fall harvest, precipitation.

9-10-3

Influence of Harvesting Time on the Food Value of Orchardgrass and Timothy

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This investigation clarified the effects of harvesting time on the food value of orchard grass (Dactylis glomerata) and timothy (Phleum pratense). The variety representing each type of grass was Tammisto. Two nitrogen levels, 50 and 100 kg per hectare, were chosen. The experiments were carried out at Olustvere Experiment Station (58° 22,) in the Soviet Republic of Estonia and at South Savolax (61° 40) and North Ostrobothnia (64° 40) Experiment Stations in Finland.

The dry matter yield at the three experiment stations during the years 1977-79 were on the average 7700 kg per hectare in the case of timothy and 7550 kg per hectare in orchard grass.The growing of timothy and orchard grass was nearly twice faster in early summer than in the middle of summer and in late summer. In early summer timothy yielded on the average 180 kg per hectare and orchard grass 130 kg per hectare of dry matter in a day. In the selective regression analysis the most important weather element affecting yield forming was the temperature sum (over + 5 °C). The precipitation sum from fertilization to harvesting was also a significant factor.

The fastest decrease in crude protein content happened in early summer, in the case of timothy on the average 0.40 and in orchard grass 0.45 percentage in a day. In the selective regression analysis the most important factors affecting protein content were the temperature sum and the amount of precipitation from fertilization to harvesting. The highest correlation between crude protein content and the temperature sum was in the spring yield (timothy $r=0.72^{xxx}$ and orchard grass $r=0.75^{xxx}$). In spring yield timothy had an increase of 0.37 percentage in a day in fiber content and orchaard grass an increase of 0.35 percentage . In the middle of summer and in late summer timothy had only an increase of 0.09 percentage in a day in fiber content and orchard grass an increase of 0.13 percentage. The most important factor affecting fiber content was precipitation from fertilization to harvesting. The regression model also often included the temperature sum.

The digestibility organic substance(in vitro) in spring yield decreased in the case of timothy by 0.50 and in orchard grass by 0.61 percentage in a day. In the middle of summer and in late summer the digestibility decreased only by 0.20-0.28 percentage in a day. The temperature sum affected the digestibility of organic substance most. The highest correlation between the digestibility of organic substance and the temperature sum was in spring yield ($r=0.85^{xxx}$). In the middle of summer and in late summer the precipitation sum was also often one significant factor.

Key words: orchard grass, timothy, harvesting time, food value, protein content, fiber content, digestibility.

9-10-4

China's Grassland Types: Their Locality and Improvement

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China's natural grassland is mainly distributed over the temperate zone to the west and north of the isohyet of 400 mm annual rainfall and over the hilly subtropical areas in the southern part of the country, amounting to 37 per cent of the country's total land area. Since 1949, comprehensive survey has been conducted on several occasions in Tibet, Inner Mongolia, Xinjiang and other regions. The resource of forage plants and grassland productivity have been studied.

Types and Locality of Grassland: There are about twenty types and eight regions of grassland in China. On the natural steppe of the northern part of Mongolia-Xinjiang Plateau, the successive grassland types from the east to the west are as follows: meadow grassland, steppe, desert grassland and desert; where deserts extend into the mountains there are mountain grassland and alpine meadows. In the Tibet Plateau, there are alpine meadows, grassland and alpine deserts. In the soggy and peaty regions all over the country, there have developed swampy meadows, wooded meadows and tufty swamps. In the tropical and subtropical area, there are hilly scrubby or wooded grassland and savanna.

Salient Features of the Natural Grassland: (1) Variance in productivity due to geographical location. In general, areas where their annual rainfall is equally 100 mm, their grassland yield is on average 750 kg of fresh grass per hectare per year. China's grassland, therefore, can be classified into two types: meadow, grassland and steppe whose yearly fresh grass output >1,500 kg/ha; and desert grassland, desert and alpine meadow whose yearly fresh grass output <1,500 kg/ha. The total area of the former to the latter is a 3:7 ratio. (2) Longer winter-spring and shorter summer-autumn season and scarcity of winter pastures in the northern grassland region. The grazing capacity of the winter pasture is low. (3) Inter-annual climatic changes fluctuate grass output greatly.

Improvement of the Grassland: The overused grassland of Yanchi has witnessed a 181 per cent increase of grass output at the end of a two-year rehabilitation. Disking and seeding have also improved the Aneurolepidium grassland. The speed of permeability, hardiness, volume weight and water holding capacity of the grassland soil were improved and the grass output increased 385% as compared to that of the undisked plots.

Key words: grassland, types, locality, improvement, China.

9-10-5

Experimental Trial in Besnate Farm: Analytical Results and Grazing Studies

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In our previous studies we have pointed out the relationships between chemical composition of soils and forages and the variability in chemical composition among species and among plots within a single species. In Besnate on one experimental farm we have grown 17 species to verify their analytical characteristics in order to evaluate their usefulness for animal feeding. The 17 grasses were sown in three replicate plots in a randomized block design. At physiological maturity all grasses were collected, dry matter yield was measured and chemical composition (crude protein, crude fats, crude fiber, N-free ext., Ca, Mg, Na, Si, K, P, Pb, Zn, Cu, Cr, Mn, Fe, N-NO_3, Cl, SO_4, A/B, sterols, amminoacids, fatty acids) was determined.

After the analytical work, we collected sufficient information to arrange a grazing study. We have observed the quality and the quantity of herbage intake by a grazing horse, studying the basis of his choice, the troubles owing to the altered ratio between the different elements and the excesses or deficiencies of the diet when based only on the sowed species.

Key words: plant composition, forage quality, acceptability, horses.

9-11-1 Dynamics of Herbage Growth and Senescence in a Mixed-Species Temperatue Sward Continuously Grazed by Sheep

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Four perennial ryegrass (Lolium perenne L.), Poa annua L., white clover (Trifolium repens L.) swards with herbage mass ranging from 500 to 1700 kg OM/ha were established and maintained in as near steady state as possible by continuous but variable stocking with sheep in order to study the influence of herbage mass on rates of herbage growth (G), senescence (S) and net production (NP), and on species balance. Estimates of G, S and NP were derived from measurements on individual grass tillers and clover stolon growth sites.

The mean contributions to total G were 54, 20 and 4 (±1.6) kg DM $ha^{-1}day^{-1}$ for ryegrass, Poa and clover respectively. The low clover growth rates were due to low population densities, and Poa had lower population densities and lower individual tiller growth rates than ryegrass. The ratio of senescence to growth was 0.47, 0.32 and 0.11 for Poa, ryegrass and clover respectively.

The combined species G increased with herbage mass in an asymptotic manner towards a maximum of 118 kg DM $ha^{-1}day^{-1}$ and S increased linearly from 17 kg $ha^{-1}day^{-1}$ at 500 kg DM ha^{-1} to 41 kg at 1700 kg OM ha^{-1}. NP increased rapidly to a predicted maximum of 70 kg DM $ha^{-1}day^{-1}$ at 1230 kg OM ha^{-1} and then declined slowly.

The results of this experiment suggest that there is limited scope, within practicable limits, for improving rates of net herbage production in temperate swards by manipulation of the herbage mass maintained under continuous stocking management.

Key words: herbage production, dynamics, perennial ryegrass, Poa annua, white clover, continuous stocking, sheep.

9-11-2 A Comparative Evaluation of Six Ryegrass Cultivars Under Grazing and Conservation Management

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Meat and dairy products command overriding importance in the Irish agricultural economy. They are primarily derived from Irish grasslands which occupy 89% of the arable land area. Use of improved grass cultivars is probably the best means of increasing grassland output once the basics, optimal fertiliser use and high stocking rates, have been met.

Objective identification of superior cultivars, is the responsibility of state agencies. A recommended list, published annually in Ireland, presently contains 47 ryegrass cultivars. There is some doubt, however, that results from small-plot cutting trials can be extrapolated to equivalent performance by grazing animals. Hence, the desirability of evaluating some of the more promising grass cultivars using animal production parameters. The objective of this research has been to evaluate six ryegrass cultivars in terms of their carrying capacity and persistence as grazed herbage and conserved winter feed. A simple linear model for the gain-stocking rate relationship was used wherein extra carrying capacity, i.e. the increased number of animals carried at a given level of performance, is regarded as a reflection of extra forage produced.

High yielding cultivars were selected on the basis of heading date and ploidy. These were sown in monoculture and grazed by young steers stocked at moderate to high stocking rates over 3 years. Conserved herbage was fed to groups of heavier steers overwintering on slatted floor accommodation. Animal liveweight or carcase gains were compared and cultivar persistence was monitored annually via botanical analysis.

Results indicated superiority in carrying capacity and persistence of Vigor over the control S24. A hybrid, Sabrina, showed inferior carrying capacity and persistence as grazed herbage but performed better when fed as silage. There was a striking contrast in seasonality of growth between S24 and Vigor as shown by the animal performance data. Differences between cultivars were small in the silage feeding experiment.

The performance of Vigor shows that this type of late-heading, persistent cultivar can be recommended to growers looking for long-term leys with good mid-season production. Tetraploid hybrids (perennial - Italian) may produce well in the short-term under a conservation management but are not suitable for intensively stocked grazing management systems.

Key words: ryegrass cultivars, carrying capacity, liveweight gain, persistence.

9-11-3 Effect of Sheep and Cattle Grazing on a Mixed Pasture of Perennial Ryegrass, Kikuyu and White Clover

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Mixed pastures of perennial ryegrass (*Lolium perene* L.), Kikuyu grass (*Pennisetum clandestinum* Hochst.) and white clover (*Trifolium repens* L.) are commonly found within warm zone areas of New Zealand but are frequently disliked because of problems associated with Kikuyu dominance.

A grazing experiment was conducted to provide basic information on the manner in which these swards respond to cattle and sheep grazing especially at high levels of utilization. The pastures were rotationally grazed with young sheep or cattle at 2 stocking levels (high vs. medium) in each year from 1970-75, with stocking rates being adjusted twice yearly according to seasonal pasture growth rates.

The pastures grazed with cattle produced 18% more total annual dry matter (DM) than those grazed with sheep, although the advantage was largely confined to the summer and autumn when Kikuyu was the active grass component of the swards.

High stocking levels of both sheep and cattle reduced annual yield by 25% although there was minimal effect in summer. The level of stocking effect was greater in sheep pastures in winter, compared with those grazed by cattle, although there were no differential effects in other seasons.

The botanical composition of the mixed pastures in spring was greatly altered by grazing treatment. Perennial ryegrass content was greatest in less heavily stocked sheep pastures and Kikuyu increased, at the expense of ryegrass, in the more intensely stocked cattle pasture. Annual Poa (*Poa annua* L.) content was higher in sheep than cattle pastures although this component increased in all treatments over the experimental period. White clover content was variable between years but in general was lower in sheep pastures and occasionally lower, overall, in the more heavily stocked treatments.

The results of this experiment suggest that the maintenance of a balanced subtropical/temperate grass mixture cannot readily be achieved by moderately high stocking levels of either sheep or cattle and that the pastoral changes induced would require compensatory changes in farming practice if high production levels are to be sustained.

Key words: sheep, cattle, stocking rate, perrenial ryegrass, Lolium perenne L., Kikuyu grass, Pennisetum clandestinum Hochst., white clover, Trifolium repens L., mixed pastures.

9-11-4 Effects of Level of Nitrogen Fertilizer on Annual Winter Pasture (Oats - Ryegrass) and Summer Pasture (Millet)

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Two experiments were conducted with lactating Holstein cows to study the effects of different levels of nitrogen fertilizer (urea) on annual pasture (Expt. I - oats (Avena byzantina) and ryegrass (Lolium multiflorum Lam.)). (Expt. II - millet (Pennisetum americanum Schum.)

Base fertilizer (8-28-18) was applied and at the five-leaf stage three levels of nitrogen (N) (75, 150 and 225 kg/ha) were applied. The millet pasture followed the oat plus ryegrass pasture with the N-treatments being maintained in the same areas. Two hectares were planted for each treatment (total, 6 hectares).

In Expt. I, twelve lactating cows were randomly assigned to one of the three oat-ryegrass N-treatments in various sequences according to Lucas' "incomplete block switch back designs," for an 84-day trial. Each cow was offered 1 kg ration (16% CP) per 3.5 kg of milk produced.

Average milk production (kg), % milk fat (MF), % solids not fat (SNF), % protein and body weight (kg) were 11.3, 3.7, 8.1, 3.3, and 476; 11.2, 3.9, 8.2, 3.4, and 481; 11.4, 3.5, 8.2, 3.3, and 490 for treatments a, b, and c, respectively. No significant differences were observed between treatments ($P>0.05$). Average pasture dry matter availability per treatment during the trial was 2900, 3000, and 3450 kg/ha for treatments a, b, and c, respectively per period.

In Expt. II, twelve lactating cows were randomly assigned to one of the three millet - nitrogen fertilizer sequences according to Lucas' "incomplete block switch-back designs: and served as "tester" cows. Pasture pressure was adjusted according to pasture availability with other lactating cows on a "put and take" basis. The trial was 63 days in duration. One kg of feed (16% CP) was offered for each 3.5 kg of milk produced.

Average milk production, % MF, % SNF, % protein, and weight were 11.2, 3.6, 7.72, 2.93 and 462; 11.1, 3.7, 7.65, 2.96 and 457; 11.2, 3.2, 7.8, 2.5, and 454 kg respectively for treatments a, b, and c. No significant differences were observed for these parameters but for fat-corrected milk produced, treatments a and b with 10.3 kg of daily milk production were superior to treatment c with daily milk production of 9.8 kg ($P<0.05$).

Stocking rate, milk production per hectare and pasture dry matter availability per period was 2 cows, 1360 kg, 2297 kg; 3 cows, 2016 kg, 3734 kg; and 5 cows, 3712 kg and 4836 kg for treatments a, b, and c, respectively. Treatment c was different from a and b at $P<0.01$ for production per hectare.

Key words: oats (Avena bysantina), ryegrass (Lolium multiflorum Lam.), millet (Pennisetum american Schum), nitrogen fertilizer, dairy cows.

9-11-5 Animal Production with Controlled and Fixed Stocking and Managed Stocking Rates

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Grazing experiments were conducted to obtain findings to implement and improve animal-grazing management systems. The primary objectives were: Experiment I - to investigate animal production with fixed and controlled stocking and Experiment II - to study animal production and canopy characteristics with three managed stocking rates, spring stocking rates being twice as high as during summer-autumn seasons to coincide with pasture growth.

Liveweight gains/head for the grazing season were similar for fixed and controlled stocking; during a summer period, gains/head were higher for controlled stocking. Gains/head were not associated with available herbage; the canopies with fixed stocking had 28 to 82% more forage than for controlled stocking, the former being high in dead tissues and stems. Controlled stocking gave 61% more liveweight/ha than fixed stocking because more of the flush high quality forage was consumed.

Liveweight gains/head for the grazing season were higher for low than the two higher stocking rates. Gains/head during the summer-autumn season were similar for the three stocking rates even though available pasture varied, dry matter averaging 2001, 880, and 369 kg/ha for low, medium and high stocking. During spring when canopies were similar in leafiness, liveweight gains/animal were allied with available pasture. Double stocking rates during the spring season caused high gains/ha; values being lower for low than for medium and high stocking.

The findings imply that pastures and animals should be managed concurrently to supply the differential nutritional needs for classes of ruminants by controlled grazing to maintain high yields of canopies of suitable structure and leafiness. Data suggest that farms should be stocked at high levels but stocking rate within a farm should vary to control the quality, yield, and available growth for high outputs of responsive animals. Constant or fixed stocking ignore nutritional needs of ruminants and the dynamic characteristics of canopies during growth and grazing.

Key words: bluegrass, *Poa pratensis* L., white clover, *Trifolium repens* L., grazing pressure, stocking rates, pasture.

10-1-1 Energy Availability of Chemically Treated Crop Residues

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Chemical treatment of crop residues to improve their feeding value dates back to the end of the 19th century. A frequently stated goal of chemical treatment of crop residues has been to increase digestibility or "energy availability" of residues. The objective of this study was to compare apparent net energy for maintenance (NE_m) and gain (NE_g) values of untreated and chemically treated crop residues based upon performance data of 11 beef cattle feeding trials reported in the literature. The apparent NE_m and NE_g values (Mcal/kg residue DM) were computed from cattle performance and feed intake using net energy relationships of Lofgreen and Garrett (J. Anim. Sci. 27:793, 1968) and Lofgreen (Ark. Agr. Exp. Sta. Special Report No. 50:15, 1977). Residues treated included wheat straw, corn stalks and corn cobs, fed at levels of 25 to 89% of dietary DM. Chemical treatments included NaOH, NaOH and $Ca(OH)_2$, or ammonia. Differences among computed NE_m and NE_g values of untreated and treated residues were tested for significance by the paired t-test. Mean net energy values of the untreated and treated residues were, respectively---NE_m (Mcal/kg): 1.12 and 1.12 (t = .12, 10 df) and NE_g (Mcal/kg): .54 and .55 (t = .15, 10 df). The data indicate that chemical treatment of crop residues does not increase energy availability. The improvement in feeding value of chemically treated residues must be attributed primarily to increased feed intake, presumably due to an increased rate of digestion. Consequently laboratory techniques other than standard *in vitro* dry matter digestibility (IVDMD) for 48 to 96 hr are needed to screen chemical treatments for their impact upon feeding value of crop residues. Rate, not extent of digestion, must be monitored.

Key words: crop residues, chemical treatment, energy availability, growing beef cattle.

10-1-2 Factors Causing Greater *In Vitro* than *In Vivo* Digestibility of Sodium Hydroxide Treated Roughages

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Research on sodium hydroxide (NaOH) treatment of low-quality roughages generally indicates that *in vivo* digestion is lower than *in vitro* digestion. The purpose of this research was to identify factors which may cause less of the potentially digestible fiber to be digested *in vivo* than *in vitro*. Corn (Zea mays) cobs were raised to 60% moisture and treated to contain 0.0, 2.5, 5.0, 7.5 and 10.0% NaOH. Lambs were fed diets containing 80% cobs and 20% supplement, giving a complete mixed diet containing 0.0, 2.0, 4.0, 6.0 and 8.0% NaOH. The percent neutral detergent fiber (NDF) in the diet decreased linearly with increasing level of NaOH treatment. *In vivo* dry matter digestibility was 5, 12 and 5 percentage units less than *in vitro* digestibility at the 4.0, 6.0 and 8.0% NaOH level, respectively. Five abomasally cannulated lambs were assigned to a 5x5 Latin Square to measure ruminal fiber digestion as affected by increasing level of NaOH. *In vitro* digestibility of NDF reaching the abomasum increased linearly with increasing level of treatment. Rate of passage and rate of ruminal fiber digestion was measured in 15 ruminally fistulated lambs fed the same diet as in the previous trial to determine if these parameters could account for the difference in fiber digestion. Chromic oxide was used as an external marker and rumen samples were collected at 3, 6, 12, 24, 48 and 96 hr postdosing to measure rate of passage. As level of NaOH increased, rate of passage increased linearly ($P < .05$). Mean ruminal retention time decreased from 46.8 hr for the control diet to 29.8 hr for the 8% NaOH diet. When rate of passage was regressed against NaOH level, the slope of the line was 0.142%/hr with an $r^2 = .733$. Nylon bags containing 0.15g cotton fiber were used to measure the rate of ruminal fiber digestion in lambs fed the five NaOH-treated diets. Bags were removed from the rumen after 12, 24, 36 and 48 hr and the loss in weight used to estimate ruminal digestion. As level of NaOH increased from 0.0 to 8.0%, rate of ruminal cotton fiber digestion decreased from 5.42 to 2.15%/hr. When rate of cotton digestion was regressed against NaOH level, the slope of the line was -.488%/hr with an $r^2 = .934$. These data suggest that the increased rate of passage and decreased rate of ruminal fiber digestion may explain many of the differences observed between *in vitro* and *in vivo* digestion of NaOH-treated roughages.

Key words: sodium hydroxide, fiber digestibility, *in vivo*, *in vitro*.

10-1-3 Effect of Solvent Pretreatments on Digestibility and Intake of Corn Stover

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The utilization of low quality forage materials and agricultural residues for animal feeding could partially supplant other sources of animal feed materials if the digestibility is high enough. Various methods have been reported in the literature for pretreatment of residues to improve digestibility with the most prominant being the use of sodium hydroxide. The objective of the current research is the study of the effect of the addition of catalytic agents in sodium hydroxide to improve digestibility and to study animal intake. A solvent consisting of iron, tartrate, and sodium hydroxide has given over 80% in-vitro disappearance when the solvent is washed out. Tests are now underway in-vitro and in-vivo with this solvent being left in the residue. Preliminary results of these studies indicate that careful attention must be given to how such a solvent is used if an advantage over sodium hydroxide alone is to be attained. The information being obtained from these studies appears to be useful in building a foundation from which further new approaches to pretreatment of forages to improve digestibility can be developed.

Key words: sodium hydroxide, digestibility forages.

10-1-4 Evaluations of Low Quality Roughages and Fibrous Cereal Grains Treated with Various Chemicals

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Large improvements in the feeding value of low quality roughages have resulted due to their treatment with various chemicals. Chemical treatment of grains may also be a potentially useful practice. The research reported here was designed (a) to determine how "Chelating Metal Caustic Swelling" (CMCS), a non-toxic, alkaline, aqueous reagent, compares with sodium hydroxide (NaOH) in enhancing *in vitro* cellulose digestion (IVCD) of cornstalks (CS) and soybean residues (SBR), and (b) to evaluate the effects of NaOH, ammonium hydroxide (NH_4OH) and CMCS treatments of fibrous cereal grains using *in situ* techniques.

CMCS or 7.5% NaOH solutions were added to CS or SBR at chemical substrate ratios of 0:1, .25:1, .50:1, .75:1, 1:1, 3:1 and 5:1. The mixtures were allowed to react for 24 hours, after which time they were washed with water and used immediately for IVCD determinations. As concentration of chemical increased, CS IVCD also increased. At the higher chemical:substrate ratios, NaOH treatment resulted in marked increases in IVCD compared to CMCS. Treatment of SBR with CMCS resulted in either similar or lower IVCDs compared with controls. NaOH had no effect on SBR IVCD, regardless of concentration.

In situ digestion studies were conducted to determine the effect of alkali treatment on the 24-hour ruminal digestion of whole, high moisture, oats and barley. Grains treated with 6% NaOH had the highest *in situ* digestibility. NH_4OH treatment tended to reduce the digestibility of barley. Digestibility of dry, whole cereal grains was increased by treatment with 2, 4 or 6% NaOH. *In situ* comparisons between 4% CMCS and 4% NaOH-treated whole oats and barley showed that CMCS was ineffective in enhancing digestion.

In conclusion, these experiments (1) point to the marked differences in reactivity which occur when low quality roughages are treated with various chemicals and (2) show that NaOH treatment has potential as a grain processing method.

Key words: cornstalks, soybean residues, oats, barley, sodium hydroxide, ammonium hydroxide, CMCS, digestibility, *in vitro*, *in situ*.

10-2-1 Ammonia Treatment of Crop Residues

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The use of ammonia appears to provide benefits similar to those reported from treatment of crop residues with other alkaline bases, including increased animal intake, forage digestibility and animal performance, while avoiding some of the disadvantages associated with those compounds. Four sheep digestion trials, two lamb growth trials, a calf growth trial and a gestating cow performance trial were conducted using ammonia-treated crop residues. Lamb digestion trials were conducted using standard procedures in the collection and analysis of the data. In trial 1, ensiled untreated wheat straw was compared with straw treated with 6% NH_4OH. Treatment increased daily dry matter (DM) intake by 30.7% and dry matter digestibility (DMD) by 17.2%. In trial 2, untreated wheat straw was compared with polyethylene covered straw treated with 3.8% NH_3. Intake was increased 43.7% and DMD 11.4%. In trial 3, ensiled untreated cornstalks were compared to stalks treated with 3% NH_3. Intake was increased 19.0% and DMD 32.0%. In trial 4, ensiled untreated corn cobs were compared to cobs treated with 3% NH_3. Intake was increased 54.8% and DMD 3.9%. Ammonia treatment increased intake an average of 36.8% and DMD 16.1%. Lambs in a growth trial averaging 30 kg were fed 73 days on a control ration of 80% wheat straw plus 20% supplement or 6% NH_4OH treated wheat straw plus supplement. Daily gains (g) and gain/feed were 8.8, .014 and 98.0, and .113, respectively. Lambs in a growth trial averaging 27 kg were fed for 60 days on a control ration of 75% NaOH treated (4%) ground corn cobs plus 25% supplement or 75% ground corn cobs (1:1 ration 4% NH_4OH and 4% NaOH) plus 25% supplement. Daily gains (g) and gain/feed were 100, .089 and 110 and .079, respectively. Calves in a growth trial averaging 215 kg were fed 140 days on control or 3% NH_4OH ensiled cornstalks. Daily gains (kg) and gain/feed were .39, .092 and .72, .101, respectively. Spring-calving mature cows averaging 485 kg were fed in winter drylot for 77 days a ration of wheat straw or 3.8% NH_3 treated wheat straw free choice plus 3.2 kg per head daily of alfalfa-bromegrass hay. Daily gains (kg) and straw intakes (kg) were .12, 8.8 and .40, 10.5, respectively. The ammonia treatment of wheat straw, cornstalks and corn cobs increases intake, digestibility and performance of lambs, calves and cows. Methods of treatment, processing, storage and feeding will be discussed.

Key words: wheat straw, ammonia, beef cows.

10-2-2 Ammonia Treatment of Soybean Straw, Grain Sorghum Stover and Prairie Hay

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One method to improve the value of poor quality forages as a feedstuff for ruminants is by treating them with anhydrous ammonia (NH_3, gaseous). Our objective was to study the influence of NH_3 treatment of forage on nutrient digestibility.

One lot of soybean (Glycine max) was harvested for beans and the remaining straw, consisting mainly of stalks and empty seed pods, was mowed and baled. One-half of the straw was designated as untreated and the remainder treated with NH_3. In addition, smaller amounts of grain sorghum stover (Sorghum vulgare) and prairie hay (Andropogon scoparius, principal species present) were divided into untreated and NH_3 treated portions. The forage treated with NH_3 was placed upon an undersheet of clear plastic of 6 mm thickness. A covering sheet was placed on top and the stack sealed on 3 sides by rolling the 2 edges of the under and top sheets around wooden lath. NH_3 was added to the stack at a rate of 5.0% by placing a hose through a small, unsealed opening between the sheets. The coverings then were sealed and allowed to remain for 30 days. The treated and untreated soybean straws were each fed to 3 Holstein steers in digestion trials. Supplements were added to provide minimum requirements for nitrogen (N) and energy. Digestibility of straw was then determined by difference. All lots of forage were subjected to an in vitro digestibility system.

Dry matter content (%), crude protein equivalent (%) (N x 6.25), and in vitro dry matter digestibility (%) respectively for forages were: untreated soybean straw 90.4, 4.3 and 41.3; treated soybean straw 92.1, 17.1 and 50.7; untreated sorghum stover 88.6, 5.4 and 46.2; treated sorghum stover 90.7, 16.8 and 61.3; untreated prairie hay 92.3, 7.3 and 40.2; treated prairie hay 93.6, 16.4 and 53.8. The results of the digestion trials revealed coefficients of digestibility for dry matter (%), N (%), and energy (%) respectively as follows: untreated soybean straw 40.4, -3.1 and 38.0; treated soybean straw 52.0, 66.1 and 53.4.

These data indicated that anhydrous ammonia treatment at a rate of 5.0% increased in vitro dry matter digestibility of all forages tested. This observation was further confirmed for soybean straw by digestion trials with steers. Digestibility of dry matter, N, and energy were all significantly increased as a result of treatment.

Key words: anhydrous ammonia, soybean straw, Glycine max, grain sorghum stover, Sorghum vulgare, prairie hay, Andropogon scoparius, cattle, digestibility, nitrogen, dry matter, energy.

10-2-3 Improving Hay Quality by Ammoniation

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Experiments were conducted to determine the effect of hay ammoniation on hay consumption and weight gain by steers when the hay was fed unsupplemented and supplemented with energy and protein. Mature orchardgrass (Dactylis glomerata L.) hay was baled in early June 1979. Approximately 1000 rectangular bales were stacked on a sheet of polyethylene. The stack was then covered with an additional sheet of polyethylene and the top and bottom plastic sheets sealed together. A quantity of liquid anhydrous ammonia equal to 30 g/kg of hay was injected into the stack.

Approximately 7 weeks after treatment the hay was uncovered and allowed to aerate for 3 days. The hay was then fed to weanling steer calves weighing approximately 225 kg. Similar hay baled from the same field and unammoniated was fed to separate groups of steers. Both the treated and untreated hays were fed unsupplemented, supplemented with 1.80 kg of corn/head daily, and supplemented with 1.35 kg of corn and 0.45 kg of soybean meal/head daily. The feeding trail lasted 90 days.

Ammoniation increased total nitrogen concentration of the hay from 1.12 to 1.96%. Apparent dry matter digestibility was increased from 47.7 to 54.8%. Cellulose and hemicellulose digestibilities were increased from 49.5 to 62.1% and from 49.8 to 71.7%, respectively, by ammoniation. The digestibility of nitrogen added to the hay during treatment was slightly greater than digestibility of the native nitrogen.

Animals fed ammoniated hay consumed 17% more dry matter daily than animals fed untreated hay. Consumption averaged 66.2 and 77.1 $g/kg^{0.75}$, respectively, for the untreated and ammoniated hays. Animals consuming ammoniated hay gained 0.21 kg/day more than animals consuming untreated hay. Corn grain, fed at 1.80 kg/head daily, increased daily gain of animals consuming treated hay from 0.16 to 0.45 kg. Similar supplementation of animals consuming ammoniated hay increased daily gain from 0.37 to 0.69 kg. Protein supplementation did not further increase the weight gain of animals consuming ammoniated hay. Apparently the nitrogen added to the hay during ammoniation was utilized well enough to preclude the need for additional protein supplementation.

Key words: weight gain, digestibility, fiber, intake, hay supplementation.

10-2-4 Floodland Grass Utilization for Feed Production Under North Siberia Conditions

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In the North regions of Siberia we have favorable conditions for developing animal husbandry. There are many hay fields and pastures on the floodland of the Siberian rivers (Ob, Irtish and Yenisey), with high potential productivity. However, the climatic conditions in this zone (wet soils, high humidity and flooding periods of 40 to 80 days) complicate the harvesting of high quality forage. The purpose of our experiments was to develop the technology of moist hay preservation as well as enriching grass meal with synthetic nitrogenous substance (SNS).

A new method of enriching grass meal with SNS is elaborated to prepare amidograss additives with protein content up to 30%. Our task was to determine the stability of available nutrients and the quality of preserved forage after lengthy storage and the effects of feed on animal health and animal products.

Preserving characteristics of formic and propionic acids and bacitracin 30 were determined. The acids were applied to sundried vegetable mass at the rate of 0, 0.1, 0.5, 1.0, 1.5 and 2.0% dry matter. Bacitracin was applied at the rate of 0.01, 0.05 and 0.1% dry matter. During the first 10 days the hay temperature was measured daily. Hay samples were analyzed monthly. Nutrient levels were determined initially and after 3, 6 and 9 months of storage.

In the hay treated with SNS or formic and propionic acids at the rate of 1-1.5% there was no loss of dry matter and available nutrients, but in control samples the loss was 56.5 to 62%. Propionic acid and SNS complicated the development of moldy fungi, yeasts and putrifactive, butyric acid and lactic acid bacteria. Propionic acid and SNS appeared to be more effective in reducing fungi than in reducing bacteria. Treated forage had no effect on milk and meat quality. Digestibility of organic substance and average daily gain by animals were increased by treating the forage. Preserved hay in animal diets had no negative effect on hematologic, biochemical or clinical indices.

Protein concentrate was used for cattle feeding. Inorganic nitrogen was digested if sufficient levels of digestible carbohydrate, mineral substances and vitamins were in animal diets. Grass meal promoted good digestibility of inorganic nitrogen by animals.

The advantages of chemical treatment were proven by production experiments that showed the potential of such treatment for agriculture, especially in zones with unfavorable climatic conditions.

Treating of high moisture hay (25-35%) with chemical preservatives significantly decreased (by 2-2.5 times) the loss of nutrient substances. Enriching the vegetative mass with SNS resulted in formation of amidograss substance which is of value to ruminants.

Key word : preservatives, propionic acid, butyric acid, bacitracin, synthetic nitrogen, animal performance, harvest technology, forage quality, storage losses, nitrogen enrichment.

10-3-1 Effect of Delayed Sealing During the Ensiling Process on Fermentation and Dry Matter Loss

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Two experiments were carried out from 1976 to 1980 to ascertain the effect of delayed sealing on fermentation, DM loss, digestibility and silage intake.

1) The effect of delayed sealing (up to 72 hours) of grass and corn silage in laboratory silos on fermentation quality with storage temperatures at 15 and 30 C, moisture content from 49 to 85 %, WSC content ranging from 11.1 to 17.5 % and with and without an addition of 0.25 % formic acid were tested. In all cases delayed sealing resulted in the production of poor quality silage with high pH values and low lactic acid content. Moreover, silage quality deterioration was accelerated by increases in delay time, storage temperature, moisture content and by lowering of WSC content of the ensiled materials. Formic acid addition before ensiling eliminated silage quality deterioration caused by the delayed sealing.

2) High moisture Italian ryegrass was harvested with a cylinder harvester at early heading stage and ensiled three times in each of two 4.5 m^3 experimental tower silos. This green forage contained 14.1 % DM, 15.1 ± 1.2 % WSC and 13.6 ± 0.8 % crude protein on a DM basis. Silo I was sealed immediately after each ensiling by using the plastic bag liner method, while silo II was sealed after 48 hours delay at each ensiling (open for a total of 144 hours) using the same plastic bag liner method.

During the ensiling process in the silo where sealing had been delayed maximum fermentation temperature in the middle layer was 34.9 ± 1.6 C and 50.8 C in the top layer. By comparison, in the silo that had been sealed immediately maximum temperature was 22.0 ± 0.8 C. Delayed sealing produced silages of high pH values with high butyric acid and VBN and low lactic acid content. DM losses during ensiling were also high in these aerated silages.

The DM digestibility (in vivo) and intake of silage from the silo which had been sealed immediately was slightly higher, though not statistically significant, than the aerated silage.

From these experiments, it is concluded that delayed sealing of a silo has not only an immediate effect on the upper layers of the ensiled mass but can also cause deterioration of the lower layers even after sealing has been accomplished. Moreover, the effect of delayed sealing on fermentation and DM loss may be increased by attendant conditions of warm weather, low DM and WSC contents of the ensiled materials.
More detailed experimental research is required.

Key words: silage, delayed sealing, silage fermentation, dry matter loss.

10-3-2 Interrelationships Between Pattern of Fermentation During Ensilage and Initial Crop Composition

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Relationships between crop composition and silage composition were examined for 255 silages made at the Grassland Research Institute from 1968-78 without additive.

A test was made of the model of Weissbach et al. (Proc. 12 Internat. Grassld Congr. 3, 663-673) in which silage characteristics were related to the percentage of dry matter in the crop (DM) and the ratio of sugar (Z) to buffering capacity (PK). Although these factors accounted for significant variance, the percentage accounted for was low at 32% for lactic acid (% total acids), 29% for Flieg Index, 18% for ammonia-N (% total N) and 10% for butyric acid (% total acids). Consideration of the separate effects of DM, Z and PK accounted for a slightly higher percentage of the variance, except for butyric acid, where the Weissbach model gave the better fit. Variation in Z (% of fresh weight), appeared to be more important than variation in the other factors.

Cluster analysis was carried out according to silage characteristics and the silages formed seven distinctive groups, three of which were considered well preserved and four poorly preserved. All the crop characteristics examined - DM, Z, PK, Z/PK, N (% fresh weight) and pH - varied significantly with silage group and mean values for Z were significantly higher for the three well-preserved groups than for the other groups. The percentage of poorly preserved silages decreased with increase in Z; for Z contents below 3% some 31% of the silages were poorly preserved, whereas when Z was above 3% only 8% of the silages were poorly preserved. It is concluded that Z alone can indicate in broad terms the probability of obtaining good preservation without the use of additive. Further research on physical, chemical and microbiological factors would be needed for precise predictions of the course of the silage fermentation.

Key words: crop composition, fermentation pattern, ensilage, silage composition.

10-3-3 Quality and Feeding Value of Grass Silages Made with Different Additatives

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Several grass silages were made, with the following additives:

1. Control, without additives.
2. Lactipharm, a microbiological additive.
3. Acidol, a mixture of organic and mineral acids.
4. Master Mix Ensil-ATE, an enzymatic additive.

In samples of silages, the basic components and the contents of sugar, starch, pH, ammonium, alcohol and acids were determined. The digestibility of nutrients was measured using balance methods in sheep. The evaluation of silage quality was made according to the Flieg-Zimmer scale.

The investigations showed that the silages containing acidol and Lactipharm were highest in quality and feeding value. The control treatment resulted in the poorest silage.

Key words: silage, additives, quality, nutritive value.

10-3-4 Addition of Lactobacillus Species to Aid the Fermentation of Alfalfa, Corn, Sorghum and Wheat Forages

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As preservation of forage as silage has increased, so has the use of additives to enhance acid fermentation. Many of the fermentation aids currently on the market contain microflora to insure a lactic acid fermentation. The objectives of this study are to characterize the basic patterns of fermentation in a variety of crops and to evaluate the effects of adding selected microflora to forages to enhance the fermentation. Four crops were ensiled each of 3 seasons. Alfalfa was harvested at 20-40% bloom, second cut; wheat was cut in the early dough stage; corn was cut in the soft dent stage; and sorghum was havested at an early dough stage. Treatments used during the three years of trials included a commercially prepared dried preparation of Lactobacillus acidophilus and Candida sp, a frozen commercial preparation of Lactobacillus plantarum or a Lactobacillus plantarum isolated from corn silage and prepared in the laboratory as a frozen concentrated culture. The inoculum was added at the time of ensiling at concentrations of viable populations of 10^5 to 10^7/g silage fresh weight. Fifty-five Kg of freshly harvested forage was packed in 0.1m^3 steel drums. After 1, 2, 4, 8, 16, and 32 days of fermentation one drum each for the treatment and control silage was opened for analysis. PH was determined on a fresh sample. A sample was air dried and ground for determination of dry matter, crude protein, crude fiber, crude fat, nitrogen free extract, and soluble carbohydrate. Fresh samples were used for microbiological determinations including lactobacilli, facultative anaerobic bacteria, lactic acid cocci, and yeasts and molds. The silages differ in their rate and extent of fermentation, microflora and recovery of nutrients. Corn and sorghum silages had high recovery of nutrients while alfalfa and wheat fermentations we e intermediate. Study of natural microflora of fresh forages indicated few (10^4/g) lactic acid bacteria are present in wheat but higher numbers were recovered from alfalfa (10^5/g) and corn or sorghum (10^6/g) silages. Higher populations of lactic acid bacteria ensured faster acid production and pH decline in control silages. Addition of L. acidophilus and Candida sp. had no effect on the fermentation. Addition of L. plantarum caused increases in populations of lactobacilli during the fermentation, more rapid pH declines but only slight differences in recovery of nutrients.

Key words: silage, inoculation, Lactobacillus, fermentation.

10-3-5 Effect of Formic Acid/Formaldehyde Treatments on the Nitrogenous Constituents in Annual Ryegrass Silage

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Prevention of proteolysis during ensiling is important in preserving the nutritive value of silage. Hence, the mechanism by which silage protein is protected against degradation was studied in wilted annual ryegrass (Lolium multiflorum Lam.) silage pretreated with formic acid, formaldehyde, and a formic acid-formaldehyde mixture. A method for determining optimum conditions or levels of additives for the protection of true silage protein against degradation was developed.

Raw-wilted ryegrass, control ryegrass silage, and treated ryegrass silage were extracted and fractionated under conditions previously found to maximize yield of nitrogenous constituents and minimize proteolysis during the extraction of fresh grass. Extractions were by boric acid-borate buffer at pH 8.0 with and without detergent (1% sodium dodecyl sulfate). Sodium metabisulfate, an anti-oxidant, was included in all extractions. The fractions, obtained by differences in extractability, solubility, and molecular size, were analyzed for nitrogen content; and in the case of the soluble fractions, first moment apparent molecular weights were determined by a specially designed automated gel filtration apparatus. For the forage extracted without detergent, the percentage of total nitrogen as non-extractable-insoluble residue was 72.5 for formic-formaldehyde treated silage, 65.8 for the "wilted" control, 63.4 for formaldehyde treated, 49.7 for formic acid treated, and 41.0 for the untreated silage. The percentage of total nitrogen as extractable insoluble nitrogen was 17.1 for wilted control, 12.9 for formic-formaldehyde treated silage, 7.6 for formaldehyde treated silage, 5.8 for formic acid treated silage, and 2.7 for the untreated control silage. The wilted control contained 21.7% of soluble "protein" whereas the untreated control silage contained 47.8% soluble "protein." The formic acid, formaldehyde, and formic acid-formaldehyde treated silages contained 38.1, 28.1, and 18.6% soluble nitrogen, respectively. Also, as determined by gel chromatography, the treated silages had a higher relative concentration of high molecular weight polypeptides than the control silage. With the addition of detergent to the buffer 5-14% more nitrogen was extracted and an additional 3-5% nitrogen was solubilized.

Neither formic acid nor formaldehyde protects proteins normally soluble in the plant cell nor eliminates anaerobic activity. Both treatments reduce the extractability and therefore the degradability of polypeptides associated with cell membranes and the plant matrix. At the levels employed, formaldehyde is about twice as effective as formic acid in protecting proteins, but due to the complementary nature of their mechanisms of protection, the effect on protection of combining both chemicals in one treatment is that of additivity.

Key words: annual ryegrass, Lolium multiflorum Lam., silage, formic acid-formaldehyde treatment, proteins, polypeptides.

10-4-1 Influence of Rainfall during Drying on the Chemical Composition of Alfalfa, Red Clover, and Birdsfoot Trefoil

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Rainfall during field hay drying is common in many areas of the United States; however, data are not available concerning quality losses due to leaching. The objective of this research was to study the effects of simulated rainfall during drying on the chemical composition of alfalfa, red clover, and birdsfoot trefoil hay. Plants of each species were grown to first flower in the greenhouse and the following treatments imposed: 1) control (no wetting), collected at clipping; 2) control, collected after 48 hr of drying; 3) control, collected after 96 hr of drying (96 hr control); 4) 2.5 cm rainfall applied 48 hr after clipping (forage collected immediately); 5) as in 4 but forage left in place to dry for 48 hr after wetting; and 6) wetted with 2.5 cm 24 hr and 48 hr after clipping, then allowed to dry for 48 hr. Forage was placed on aluminum screens placed over bluegrass sod to allow collection of shattered leaves.

Dry matter percentage after 48 hr without wetting ranged from 70.8% for alfalfa to 74.3% for red clover. Wetting twice (Trt. 6) reduced leaf percentage by 20.0% for alfalfa and 11.0% for birdsfoot trefoil compared with unwetted forage collected at the same time.

Cell wall concentration increased drastically in response to multiple wetting (Trt. 6). Red clover increased from 29.1% to 39.9% cell wall in response to wetting twice, birdsfoot trefoil increased from 31.0% to 40.8% cell wall, and alfalfa increased from 32.3% to 38.4%. Total sugar concentration was reduced slightly by a single wetting and more so by multiple wetting. The reduction compared with unwetted forage averaged 43.6% for alfalfa, 50.9% for birdsfoot trefoil, and 59.5% for red clover. Total nitrogen (N) concentration did not change greatly during drying in unwetted tissue of either species. Red clover N concentration increased from 2.33% for the 96 hr control (unwetted) to 2.80% in response to wetting twice (Trt. 6). A similar increase was found for birdsfoot trefoil but not for alfalfa. It is possible that the increase in N concentration results from more rapid leaching of some other cellular constituents compared with the protein.

These results indicate that legume species differ in susceptibility to quality losses due to rainfall during drying. Additional research is needed to evaluate the influence of maturity stage, mechanical crushing, and other factors on leaching, respiration, and leaf losses.

Key words: *Medicago sativa* L., *Trifolium repens* L., *Lotus corniculatus* L., *in vitro* dry matter disappearance, cell wall constituents.

10-4-2 Effects of Microwave Treatment on Drying and Respiration in Cut Alfalfa

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After forage crops are cut mechanically, they usually undergo some degree of natural drying before being stored or further processed. During early stages of drying, plant respiration continues. Treatments or management practices which hasten drying and reduce post-harvest respiration are desirable, because they minimize quantity and quality losses. Our objective was to determine the effects of brief microwave treatment on subsequent natural drying rate and respiration of alfalfa (Medicago sativa L.).

Duplicate samples of field-grown Apollo alfalfa were subjected to focused microwave energy (2450 MHz) generated at 0.25, 0.50, or 1.0 kilowatt of power for 3, 6, or 12 seconds. Control and microwave treated samples were dried at 0 relative humidity in a drying chamber. Moisture percentage and respiration rates were measured immediately before and after microwave treatment and 18 hours after treatment.

A hypothetical example is given to show that small reductions in initial moisture percentage of forage are associated with relatively large water losses. Conversely, relatively small amounts of water must be removed to dry a sample that is already less than 50% moisture.

Increasing power and time of exposure to microwave energy increased the amount of water lost during the treatment and decreased percent moisture and respiration rates in samples measured immediately after treatment. The initial treatment removed 6 to 37% of the original leaf sample water, depending on power and exposure time. Respiration was reduced slightly by weaker treatments but completely inactivated by longer, higher power treatments.

All except the weakest microwave treatment resulted in samples that contained less than half as much moisture as the controls after 18 hours at 0 relative humidity. By 18 hours post-treatment respiration rates of treated samples were half or less than half of the respiration rates of control samples, most of the treatments having completely or almost completely inactivated respiration by that time. Stem drying and respiration rates were more labile to microwave treatment than those of leaves.

We conclude that brief, focused microwave treatment removes substantial amounts of moisture from alfalfa leaves and stems, results in lower total drying time, and reduces or stops respiration. The treatments imposed had a range of effects and the resulting data can serve as a base for future calculations of power requirements and economic thresholds.

Key words: microwave, alfalfa, Medicago sativa L., drying, respiration.

10-4-3 Alternative Treatment Systems to Increase the Drying Rates of Green Forage Crops

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Forms of conditioning treatment are being developed which aim to minimise the barrier effect of the crop cuticle without sacrificing too much of the structural strength of the herbage. Effective surface abrasion and favourable windrow structure can be achieved with steel spoked rotors, which are now beginning to be offered commercially. More recently, plastic brushes have been developed because the higher population density and yielding ability of the crop engaging elements, plus the absence of metal components, appeared to offer additional advantages.

Four different brush conditioner systems have been evaluated in the laboratory and in replicated field experiments. Tuft studded brushes using trilobar filaments lifted and conveyed the crops more effectively than full brushes and carried the conditioning effect deeper into the crop layer. With regard to crop drying rate improvement and digestible dry matter yield, levels of effectiveness have been recorded with brush systems which exceeded those obtained with commercial conditioners, even in wet weather.

Cost of the plastic elements is low. Durability is already near acceptance by farmers and has the potential of being improved substantially further.

Key words: mower-conditioner, hay conditioning, plastic brush conditioner, drying rate improvement, green crop treatment, forage mowing and conditioning.

10-4-4

Hastening Hay Drying

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The objectives of these studies were to increase the drying rate of cut alfalfa by treating with chemical solutions and to examine factors that influenced drying. Time to dry and drying rate of cut alfalfa were studied under laboratory and field conditions. Treatment consisted of spraying the cut alfalfa with methyl esters of long chain fat acids, an emulsifier alone and/or in combination with a potassium carbonate solution. Alfalfa sprayed with solutions of each chemical under specified conditions increased drying rate and decreased drying time to 60 or 75% dry matter or average dry matter during the trial. The combination of 0.2M potassium carbonate plus 2 to 4% methyl ester plus 0.25% emulsifier produced faster drying than either component alone of that concentration. A successful application rate of that solution was 4% of the weight of the fresh sprayed alfalfa.

Grass had faster drying rates than did alfalfa but the three component spray solution did not enhance the drying of grass as it did for alfalfa. Mature alfalfa dried faster than alfalfa in the 1/5 bloom stage. Field trials showed that spraying would hasten drying of alfalfa at both growth stages. Heavily crimped alfalfa dried more quickly than did lightly crimped alfalfa. When sprayed drying was hastened and both crimpings were about equal in drying rate.

The drying measurements were made by weighing the treated alfalfa on a screen at intervals as it dried in the field or laboratory. Under field conditions significant correlation coefficients between water content (weight of water ÷ weight of dry matter) and other variables at time "T" were: a) time since cutting (-.82); b) amount of sunshine (-.24); c) vapor pressure deficit (-.20); d) initial moisture content (+.29) and e) relative humidity (+.19). Multiple regression equations indicated that methyl esters and potassium carbonates hastened a decrease in moisture content and that the laboratory and field trials were from different sample populations probably due to differing environmental regimes during drying. In normal field drying hay three independent variables (relative humidity, initial moisture content and time since cutting) accounted for 75% of the variation in moisture content. Inclusion of 8 to 10 variables in the regression equation increased R^2 to 82. Spray treatment allowed improved quality of hay to be made. This type approach should provide guidance in evaluating factors influencing the drying rate of forages.

Key words: alfalfa, drying, hay quality, methyl esters, potassium carbonate, drying forages.

10-5-1

Wet Fractionation of Alfalfa: A Direct Forage Harvesting System

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Precipitation during hay drying or silage wilting reduces alfalfa forage yield and quality. A wet fractionation forage system, under development at the University of Wisconsin, is designed to reduce the weather dependence of alfalfa harvest and to produce a usable protein concentrate which can be fed to ruminants or to monogastrics.

In this system, fresh forage is macerated and pressed to remove approximately 50% of the moisture. A forage product containing 32-38% dry matter (DM) results which can be ensiled directly. In addition the protein contained in the plant juice can be coagulated and removed. The remaining deproteinized juice contains large quantities of mineral nutrients which can be returned to the soil.

This process, termed wet fractionation, has several potential advantages: 1) less weather dependent harvesting which minimizes harvest losses, 2) reduced harvesting time, 3) reduced fertilizer requirements, and 4) ability to harvest protein from land unsuited to row crops because of slope.

Maceration of the crop is accomplished by extrusion through small openings thus resulting in rupture of plant cells. Juice expression is required to increase the DM percentage of the crop from an initial level of 18-20% to 35% which is necessary for proper ensiling. A cone type press is under development to accomplish this. Steam has generally been utilized to raise the temperature of the juice to 80 C to coagulate the protein. New protein coagulation methods being studied include fermentation and acidification by mineral acids.

Pressing reduces the crude protein concentration of alfalfa forage and increases the neutral and acid detergent fiber concentration compared with field wilted, ensiled alfalfa. The apparent digestibility of pressed forage dry matter averaged 61.9% compared with 62.8% for wilted silage. When formic acid (0.6% w/w) was added to the pressed forage at ensiling the dry matter intake was increased to a level similar to that of wilted alfalfa silage.

Deproteinized juice from alfalfa has been found to contain considerable quantities of nutrients which can be reapplied to alfalfa or other crops as a fertilizer. Deproteinized juice from the heat coagulation process from first crop alfalfa grown on high fertility soil contained 0.021% P, 0.232% K, and 0.012% S. Juice deproteinized by fermentation contained 0.083% P, 0.515% K, and 0.055% S but also contained 0.40% N compared with 0.09% N in heat deproteinized juice. Research is under way to evaluate juice from other deproteinization methods.

The goals of this ongoing research project are to improve the quality of alfalfa forage, to reduce the weather dependence of the harvest process, and to extract a usuable protein product.

Key words: alfalfa, *Medicago sativa*, forage harvesting, protein, fractionation, digestibility.

10-5-2 Stage and Tendencies in Mechanization of Forage Harvesting in the German Democratic Republic

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A major problem in many countries is the manufacture of more nutrients for animal production without increasing cultivated acreage or manpower. In the period 1949 to 1978 the G.D.R. succeeded in doubling fodder plant production while reducing manpower by more than half. Applied chemistry and land improvement contributed extensively to such positive development.

Emphasis on mechanization of forage harvesting is increasing with machines being developed to accomplish harvesting and preserving with minimal losses. The techniques include: fresh-forage harvesting for feeding and ensiling; wilt-forage harvesting for ensiling; and hay-making.

Fresh cut fodder is produced and fed at comparatively lower costs and without preservation losses. Self-propelled forage harvesters have proven useful, especially for supplying forage for the big animal production plants.

Silage corn is the choice fodder plant for fresh cut forages. Admixing of urea with the maize-forage enhances the fodder quality for cattle feeding purposes. Wilt-forage harvesting for silaging utilizes the energy from the sun and wind to improve silages from grasses and fodder plants. The drying or wilting process can be hastened by a swather machine which uses an oscillating cutting unit that crushes the stalks to achieve pre-wilting. Fresh and wilted ensilages are stored in reinforced horizontal hoppers. The distribution and compacting is accomplished with tractors mobile. The high costs of tower silos makes this type of minor importance for the future.

In the German Democratic Republic the goals for mechanization of forage harvesting are as follows:

- increasing efficiency
- reduction of crop losses
- maximum utilization of natural energy sources for the ensiling processes
- increased safety
- improved energy efficiency
- reduction of specific fuel consumption and mass-power factors.

Key words: forage harvesting, energy requirements, efficiency.

10-5-3

Comparison of Conservation Methods Under Controlled Practical Conditions

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Forage quality gets more and more important for utilizing the increasing yield potential of ruminants, especially in dairy production. Therefore comparisons of the most common methods of forage conservation - direct cut and low moisture silage, barn dried hay and dehydration - have been carried out for several years to precisely evaluate their different effects on forage quality and system losses. The experiments were run under practical, but strictly controlled conditions. A grass mixture was used as forage, always cut at one day for all treatments. Cutting time of the crop was additionally varied from "shooting" to "blossom".

Parameters determined in all experiments were: Nutrient content and digestibility before and after conservation, losses of dry matter and net energy. In three experiments forage intake by dairy cows was measured.

The experiments show that nutrient content is mainly determined by cutting time with a reduction of organic matter digestibility by 10 points and net energy content by 1.2 MJ//kg DM in the range from early to late cut. This is markedly more than the maximum decrease by preservation methods with 3 points of digestibility and 0.4 MJ/kg DM net energy using optimum technology. Suboptimum conditions as unfavourable prewilting weather, poor fermentation or overheating in the dryer or silo may result in an additional reduction of 3 to 6 points digestibility and 0.4 to 0.8 MJ/kg DM net energy.

Net energy losses reached 25 % in direct cut silage, and were practically equal with about 15 % for the other methods under good weather and fermentation conditions. But unfavourable weather can easily increase the losses of the prewilting methods to the level of direct cut silage.

Feeding experiments underline the importance of early cut, as late cut reduces intake and utilization. There has been reached a better intake with low moisture than with direct cut silages.

The experiments allow to draw the following conclusions:

- Roughage quality is more influenced by cutting time than by preservation methods.
- Low moisture silage and barn drying of hay allow to provide a forage equal in quality to dehydrated grass, and at equal losses.
- Weather risk during prewilting should be cut down by new efforts to speed up this process.

Key words: silage, hay, dehydration, comparison, grass, nutrient content, losses, cutting date

10-5-4 Harvesting and Processing Effects on Alfalfa Protein Utilization by Ruminants

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Alfalfa (medicago sativa) is an efficient and important means of producing supplemental protein for ruminants. This research was undertaken to characterize the value of alfalfa protein for ruminants and how the protein is affected by different harvesting or processing regimens. The effects of maturity (PRE, 1/10, 1/2 and FULL bloom) and processing method freeze dried (FD), sun cured (SC) and oven heated (H)) on percent nitrogen (N), acid detergent insoluble N (ADIN), in vitro rumen ammonia release (NH_3), and in situ rumen protein degradation using dacron bags (Bag) were studied on irrigated alfalfa harvested over two years. Plants were separated into leaves and stems after harvest or processing and analyses conducted on each. Nitrogen decreased ($P < .05$) and ADIN increased ($P < .05$) as plants became more mature. Leaves contained approximately 2.5 times as much N as stems. Processing (SC and H) reduced ($P < .05$) protein degradability measured by NH_3 and Bag. Heating produced greater decreases in protein degradability than SC. Leaves responded more to processing methods than stems. Two experiments were conducted to assess heat dehydration effects for steer calves (200 kg). Low protein diets (60% corn cobs and 20% corn) were supplemental to 11.5% crude protein with either urea, or combinations of SBM and urea or dehydrated alfalfa and urea. Data for both experiments were pooled. Daily gain (kg) and feed/gain were: .41, 15.23; .47, 12.60 and .54, 11.18 for urea, SBM and dehy, respectively. Protein efficiency values are calculated as the added gain of the test protein animals above the urea control divided by the amount of test protein per day. Protein efficiency for SBM was .203 and .547 for dehy. These values demonstrate that heat dehydration increases the value of alfalfa protein for ruminants by decreasing ruminal protein degradability. The last set of experiments evaluated the effects of mechanically removing solubles from alfalfa and subsequent heat dehydration on the value of alfalfa protein for ruminants. N balance experiments with lambs showed that N digestibility of the press cake alfalfa (PC) was reduced ($P < .05$) compared to regular dehy, SBM or urea, but that N balance was not negatively affected compared to regular dehy or SBM. The protein (P) present in the liquid from the mechanically squeezing of alfalfa can be harvested. The resultant liquid, called brown juice (BJ), is partially concentrated and can be dried on the PC. The last experiment tested the efficiency of protein utilization of PC, PC + BJ, PC + BJ + P and normal dehy in steer calves (10 animals/trt). SBM and urea were included as positive and negative controls. Daily gain and feed efficiency were: urea, .63, 8.22; SBM, .66, 7.71; dehy, .71, 7.81; PC, .77, 7.23; PC + BJ, .78, 7.12 and PC + BJ + P, .74, 7.29. Protein efficiency values were: SBM, .43; dehy, 1.27; PC, 1.48; PC + BJ, 1.64; and PC + BJ + P, 1.37. These data demonstrate that removal of solubles from alfalfa does not decrease the value of the protein remaining for ruminants and secondly, confirms and emphasizes the positive effect of heat dehydration of alfalfa protein for ruminants.

Key words: alfalfa, Medicago sativa, rumen protein degradability, heat dehydration, maturity.

10-5-5 Round Baling from Field Practices through Storage and Feeding

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The purpose of this research was to fill technical information gaps for field practices, preservation of feed quality, and winter feeding of round bales. A model analysis compared labor and fuel requirements for round and rectangular bale systems. Round baling reduced harvesting, transport, and handling labor by 1/2 but increased fuel use by a factor of 1.6. Field baling losses averaged 10% for round bales compared to 3% for rectangular bales. All DM losses from mowing through feeding of round bales, including 6 months weathering, were 41% which reduced DM recovered from labor and fuel inputs. Considering DM available and acceptable as feed, round baling required 80% of the labor and 200% of the fuel of rectangular baling. However, labor demands during field harvesting were reduced by round baling.

Field investigations of round baling included 2 machine sizes, various baling rates (kg/min), chemical preservatives, and measurements of feed quality and DM losses. Baling losses decreased as baling rate increased, either from double and triple windrows or higher field speed. Greater raking losses for double and triple windrows displaced DM saved by higher baling rates. Therefore, overall field losses were similar for various baling rates. Bale weight and density decreased as baling rate increased. A 1% acid treatment (propionic and acetic mixture) for high-moisture round bales significantly reduced DM losses and improved feed quality over untreated field-dried bales. Feeding experiments with beef brood cows indicated that preservatives significantly increased acceptability and that feeding untreated field-cured round bales after 6 months outdoor storage required 1/3 more DM than rectangulr bales from the same field but stored indoors. Weathering of the round bale surface and bottom spoilage significantly reduced DM, feed quality, and acceptability of that material. Bale interior portions maintained feed quality comparable to bales stored indoors.

Key words: hay harvesting, round bales, labor, energy, nutrition, preservatives, cattle feeding.

10-6-1 Compaction in the Ensiling of Forage

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In silage making the density of the forage is important for the efficient utilization of silo capacity, the load on the structure, fermentation and the risk of air penetration.

In the various silage storage systems, compaction is achieved in different ways. Compression can be continuous, intermittent or a combination of these two.

In tower silos continuous pressure is exerted by the dead weight of the fodder column on top. In trench silos the forage is usually compressed intermittently by the tractor filling the silo. In the case of high trench silos additional, continuous pressure is exerted by the weight of the fodder column on top. In the case of continuous compression compaction can be expressed by the following formulas:

$$f_t = A_t + B_t (\log p)^2 \qquad [1]$$

when $A_t = a_1 + a_2 \log t$ and

$B_t = a_3 + a_4 \log t$.

f_t = forage dry density (kg dm/m^3) after t hours of compression.
p = vertical pressure (kN/m2)
$a_1 - a_4$ = coefficients related to the type of silage.

In case of intermitten compression compaction is affected by load pressure, load time and the number of times the fodder is compressed. For a given load pressure the relation is:

$$f_n = a_1 + a_2 \ln n \qquad [2]$$

Influence of pressure and time can be described by

$$f = a_3 + a_4 \ln t + a_5 (\ln p)^2 \qquad [3]$$

the following applying to formulas [2] and [3]:
n = number of times the fodder is compressed
f = forage dry density kg dm/m^3
t = load time (s)
p = vertical pressure (kN/m^2)
$a_1 - a_5$ = coefficients related to the type of silage.

The relation of the coefficients to the type of silage (moisture content, chop length, stage of maturity in the case of continuous and intermitten compression) will be discussed in greater detail.

Key words: ensiling, compacting, predicting compaction.

10-6-2

Evaluation of Forages Ensiled in Concrete Stave and Oxygen Limiting Silos

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This study evaluated corn and triticale silages stored in concrete stave and oxygen limiting silos during the 1978-80 period in terms of the effect of environmental conditions in each silo on silage stability and feeding value. Weekly measurements of intake, production, silage temperature and yeast and mold content were made for each silage. Stability was determined monthly. Silo type had no effect on intake or production. Silage temperatures from the oxygen limiting silo were higher, and the silage was less stable than silage from concrete stave silos. No advantages were observed for the oxygen limiting structure compared with conventional concrete stave silos.

Key words: silage, corn, triticale, storage, stability, yeast and mold.

10-6-3 The Relationship Between Silage Quality and ^{15}N-nitrate Reduction During Ensilage

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Nitrate in forage has been proved to have the disadvantage that it occasionally causes poisoning to ruminants. Our recent studies, however, have shown that a high concentration of nitrate inhibits the butyric acid fermentation to the advantage of the silage quality. This work was undertaken to see the relationship between silage quality and the pattern of nitrate reduction during ensilage.

About 140 g of orchardgrass chopped 0.5 cm long was mixed with 0.05 % (W/W) of $K^{15}NO_3$ (96 atom % excess) and put in a 250-ml glass bottle, which was immediately sealed to prepare "control silage" or sealed after 24 hours to prepare "air-exposed silage" with a rubber stopper fitted with a fermentation trap for gas absorption. "Glucose-added silage" was prepared as the control silage except that 2 % (W/W) glucose was added. The bottles were kept at 30 °C and then opened after 1, 2, 4, 7 and 30 days. Nitrate, nitrite, ammonia and nitric oxide were determined by the Devarda method, and ^{15}N by the optical emission spectrometric method.

The pH drop and the lactic acid production were significant only in the control and glucose-added silages within 2 days. Addition of glucose improved the silage quality and exposure to air deteriorated the quality as evidenced by the determination of pH, organic acids and ammonia. The nitrate-^{15}N decreased rapidly within 2 days to 0.3, 0.5 and 17.1 % in the air-exposed, control and glucose-added silages, respectively. Production of small amounts of nitric oxide-^{15}N was observed only in the control and glucose-added silages at the 1st day and the 2nd day, respectively. Ammonia-^{15}N at the 30th day amounted 97.7, 71.5 and 58.5 % in the air-exposed, control and glucose-added silages, respectively.

The pattern of nitrate reduction to nitrite, nitric oxide and ammonia during ensilage is closely related to the silage quality. The better the silage quality is, the smaller is the extent of nitrate reduction to ammonia and the larger is the production of nitric oxide.

Key words: orchardgrass, silage, nitrate, nitrite, nitric oxide, ammonia, nitrogen-15.

10-6-4

Nitrogen Value of Forages

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The nitrogen value of forages given as fresh herbage, hay or silage was measured to examine the changes brought about by the preservation method.

20 forages (16 grasses, 4 alfalfas, from first growth and regrowth) were cut and conserved as hays, and 6 of them were conserved at the same time as direct-cut silages with formic acid. Digestibility and voluntary intake were measured on sheep as well as nitrogen balance, ammonia nitrogen (NH_3-N) and volatile fatty acids (VFA) in rumen liquor.

The chemical composition as a % dry matter (DM) and nutritive value were, for fresh herbage and hay respectively, crude protein (CP) 14.0, 13.1 ; crude fibre (CF) 26.7, 29.1 ; water soluble carbohydrates (WSC) 8.9, 9.5 ; soluble nitrogen (SN) % total nitrogen (TN) 34.4, 36.0 ; organic matter digestibility % (OMD) 68.4, 63.7 ; crude protein digestibility % (CPD) 64.8, 58.8 ; crude fibre digestibility % (CFD) 64.9, 64.3 and voluntary DM intake g/kg $W^{0.75}$ (VDMI) 71.6, 62.7. As regards nitrogen balance, the proportion of nitrogen lost in the feces (FN) increased : 33.4 and 39.6 % nitrogen intake (NI) whereas the amount lost in urine (UN) decreased : 55.6 and 48.9 % NI, and consequently the proportion of retained nitrogen (RN % NI) did not differ from that retained with fresh herbage : 10.9 and 11.5. But due to the lower NI, RN in g/day decreased : 3.6 and 3.0. Rumen pH (pH, average per day) was unchanged : 6.58 and 6.64, as well as VFA : 83.9 and 83.1 mM/l, and acetic acid (C_2) : 69.0 and 67.9 %, propionic acid (C_3) 20.6 and 21.5 %, and butyric acid (C_4) : 7.8 and 7.7 %. NH_3-N (average per day) was higher for fresh herbage than for hay : 166 and 145 mg/l.

The silages prepared were generally well preserved : their soluble nitrogen and ammonia nitrogen contents accounted for 50.4 and 7.7 % TN. The chemical composition and nutritive value were, for fresh herbage, hay and silage respectively, CP : 13.1, 11.3, 12.1 ; CF : 27.2, 31.0, 28.7 ; WSC : 10.2, 9.0, 4.7 ; OMD : 68.4, 61.9, 68.4 ; CPD : 64.1, 56.0, 58.8 ; CFD : 63.2, 62.3, 67.2 ; VDMI : 68.7, 56.6, 57.8. As for nitrogen balance, FN increased less with silage than with hay : 36.2, 44.6, 40.8, but UN decreased in the same way : 54.4, 48.0, 48.2. This agrees with the average NH_3-N : 147, 129, 123. Finally the amount of RN % NI was higher with silage than with hay : 9.4, 7.4, 11.1, but expressed in g per day it was about the same with silage (2.5) as with fresh herbage (2.7) due to the decrease in intake, and was higher than with hay (1.5). pH was about the same for fresh herbage, hay and silage : 6.53, 6.55 and 6.63, as well as VFA : 79.2, 78.6, 77.4, while C_2 was smaller for silage : 66.5, 66.5, 62.7 ; C_3 the same : 21.7, 22.0, 22.9 ; and C_4 higher for silage : 9.2, 8.5, 10.5. These differences might be due to changes in the chemical composition of silage.

In conclusion, the amount of nitrogen retained with hay and silage was about the same as with the fresh herbage from which they were made, provided that hay was harvested in good climatic conditions and silage was well preserved.

Key words: forage, fresh herbage, hay, silage, nitrogen balance, sheep.

11-1-1 Effect of Herbage Mass and Allowance upon Herbage Intake by Grazing Dairy Cows

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An adequate supply of nutrients for grazing animals depends on the intake and nutritive value of herbage. Little information is available on the factors affecting the herbage intake of grazing cows, particularly for the grazing systems which do not involve daily change of animals to a new pasture. Our objectives were to determine the effects of variation in herbage mass (due to variation in stage of maturity) and of herbage allowance on herbage intake by grazing dairy cows and on efficiency of consumption (herbage consumed as a proportion of herbage accumulated).

From 1976 to 1979 the herbage intake of lactating cows was determined at Lelystad in 123 grazing trials and in 28 stall-feeding trials. The pre-cut swards consisted predominantly of perennial ryegrass (Lolium perenne). A sward-sampling technique was used for estimating herbage intake by cows grazing swards for 3 or 4 days, with corrections for herbage accumulation during grazing. If herbage samples were cut both with a motor scythe and a lawnmower at start and finish of grazing, accurate intake figures could be obtained.

In 1976 and 1977 the effect of herbage mass (M, kg ha^{-1}) was studied during 4 three-week periods. Within each period different levels of M were established by allowing parts of a sward to grow for periods of time of variable length. The daily herbage allowance (kg day^{-1}) was kept equal for all treatments. The treatments were compared in time within the same group of 12 cows. The experiment was performed both at pasture and indoors.

With advancing maturity M increased significantly in time. It was shown that there were no significant effects of higher levels of M on daily intake of organic matter (O) from herbage, neither by grazing nor by stall-fed cows. In early summer the herbage consumed by both groups of cows showed a decline in digestibility at increasing maturity. As a consequence daily intake of nutrients from herbage declined significantly at higher levels of M and also affected milk production negatively. However, in late summer these effects were not significant. The efficiency of consumption was not affected significantly by M, so the mass of residual herbage was proportional to M.

In 1978 and 1979 three levels of daily herbage allowance (A) were achieved by varying the area grazed at equal levels of M for the treatments. Four groups of 6 cows were used in a 8-week change-over design experiment performed twice each year. Higher levels of A had significant positive effects on daily intake of O and of nutrients from herbage and on daily milk production per grazing animal. The efficiency of consumption declined at higher A levels. High amounts of residual herbage however, had a strong positive effect on net regrowth of herbage, especially in early summer. In alternating grazing-cutting systems a high allowance may be profitable, both for the intake per animal and for the accumulation and consumption of herbage per unit area.

At a mean allowance level of 23kg day^{-1} above 4.5 cm our grazing cows consumed 13.6-14.8 kg day^{-1} of O from herbage if no concentrates were fed. This was sufficient, at the quality of herbage as in our trials, for a daily production of 4% fat-corrected milk of 22-23 kg.

Key words: herbage consumption, efficiency of grazing, herbage accumulation, regrowth, herbage allowance, stage of maturity, herbage mass, perennial ryegrass, dairy cows.

11-1-2

Forage Intake of Cattle as Affected by Grazing Pressure

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A series of trials was conducted in 1977 to examine the effect of level of grazing pressure on organic matter intake and the relationship between intake and forage disappearance. Levels of grazing pressure studied were 10, 20, 40, and 50 kg forage allowed per animal unit per day (kg/au/day) for a 14-day trial.

Standing crop of forage was measured before, during the middle, and immediately after each trial. Organic matter intake was estimated by the fecal output:indigestibility ratio technique.

Organic matter intake was highest in April. Cattle also consumed more forage in September than in July. The combination of forage quality and animal physiological status explained the changes in intake by trial. Cattle consumed approximately 12 g/kg body weight$^{.75}$ less organic matter by the end of a trial than at the beginning. A trend was exhibited for cattle under the 10 and 20 kg/au/day treatments to consume less forage by the end of trials than they consumed at the beginning of a trial.

Total standing crop declined steadily during the grazing trials, with forage availability being significantly less at the end than at the beginning or middle of the trials. Averaged over the three trials, forage losses per au per day were 8.5, 12.0, 12.7, and 16.3 kg for the 10, 20, 40, and 50 kg/au/day grazing pressures, respectively. However, daily intake averaged across all treatments, periods, and trials was approximately 9 kg/au/day. At the grazing pressure level of 10 kg/au/day, forage disappearance approximated the average daily intake, whereas grazing pressures of 20, 40, and 50 kg/au/day had forage disappearances that exceeded intake by 28, 48, and 90%, respectively. These data indicate a possibility for a two-fold increase in the efficiency of forage harvest by grazing cattle as grazing pressure is increased.

Key words: intake, forage disappearance, grazing pressure.

11-1-3 Studies on the Herbage Intake of Beef Cattle on Two Different Systems of Grazing Management

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The differences obtained in animal production under varying management systems are not always easily explained. Our objective was to obtain a more complete understanding of the grazing system so that management can be altered to achieve optimum production.

Measurement of pasture growth, herbage intake and liveweight gain were made every twenty-one days on continuously grazed and rotationally grazed systems of beef production, for three consecutive years. Two stocking rates, which varied slightly from year to year, were used on both treatments - at the start of grazing, the low being approximately 1980 kg/ha and the high being approximately 2850 kg/ha. Net herbage accumulation was measured using 0.25 m^2 quadrats cut to ground level. Digestible organic matter intake was measured using oesophageal fistulates to collect samples for digestibility analysis and a chromic oxide marker to measure total faecal production.

In all years the rotational grazing treatment produced more liveweight gain at both stocking rates than did the continuously grazed treatment. Over the three years the difference between the two systems was greatest at the high stocking rate - the continuously grazed area producing between 16 and 45% less liveweight gain per hectare, whereas at the low stocking rate the difference was only between 7.5 and 9%. There was no significant difference in the dry matter produced between the two treatments although the high stocking rate always depressed production by 3 to 9% ($P < .01$).

The higher liveweight gain on the rotationally grazed treatment could not be entirely accounted for by differences in digestible organic matter intake. On the continuously grazed treatment the digestible organic matter intake per unit of liveweight gain was 11% more on the low stocking rate and 25% more on the high stocking rate, than that on the rotationally grazed treatment. Calculations from intake and liveweight gain of the energy required for maintenance showed that in all years the animals on the continuously grazed area had a higher maintenance requirement at both stocking rates. Studies on animal behaviour partially explained this by showing that during stress periods at mid-season when herbage was scarce, the activity of the animals on the continuously grazed treatment was higher than on the rotationally grazed treatment, e.g. grazing time and distance walked was increased by 40% and 300% respectively.

The differences obtained in beef production from varying management systems cannot be completely explained either by differences in dry matter production or by differences in herbage intake. Our studies suggest that a partial explanation may be the increased energy expenditure of animals grazing the continuously grazed treatment.

Key words:- continuous grazing, rotational grazing, dry matter production, herbage intake, animal behaviour, faecal production.

11-1-4 Investigation of Lamb Pasture Models for Carpatians and Several Aspects of the Utilization of Intensive Grass Swards by Geese

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Lamb pasture models for Carpatian regions:

The results of ten years of investigation with systems of organization of pasture management, structure of cultivars, system of fertilisation, supplementary feeding, sanitary preservation and other problems are discussed. Three models are described: A - sown grass swards with 60 lamb-stocking density per ha and production of over 1000 kg live weight gain per ha; B - natural grass swards with 45 lamb-stocking density and 700 kg live weight gain per ha; and C - middle intensive areas with two paddocks and 35 lamb-stocking density per ha. A particularly dangerous problem within this system proved to be tapeworms, Moniesia.

Utilisation of the intensive grass swards by geese:

The research program was conducted on intensive grass swards fertilized with 200 to 250 kg N/ha, divided into five paddocks. As the results showed, the geese are monogastric animals which can utilize the herbage and replace cornflour from the 30th day of age. The daily intake of the green fodder was 2.5 to 3.0 kg per goose and daily live weight gains were 30 to 50 g per goose. The best results were obtained with the races Landes Fr. and Ivl GS. Grazing geese is a very good system for their preparation for forced feeding with maize for production of goose liver, which were 41% higher for the geese pastured and with average weights of 700 g. Geese have the highest so-called "summer pasture effect" of the domestic animals. It is the coefficient of utilization of the cheap summer pasture reserves per 10 kg of live weightof animal relative to feeding the costly winter food-supplies. This coefficient is 400 times higher for geese than for beef and 40 times higher than for sheep. For this purpose natural grass swards on steep slopes are utilizable without problems or erosion. Geese are very selective with regard to grasses and herbs. The tetraploid forms of plants are of greatest importance.

Key words; forages, utilization, geese, sheep.

11-2-1 Combination Range-Pasture Management in South Florida for a Low-Energy Grassland Program

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The semi-tropical environment of South Florida is favorable for the coordinated management of a wide variety of native grass species and improved pasture forages. The decade of the 80s will emphasize the change from forage programs of high energy utilization to those of a low requirement of fossil fuels. Four decades of grassland management in South Florida have been primarily pasture establishment created from the rangeland resource. The establishment and management required substantial inputs of fossil fuel. Use and management of rangeland was largely neglected. Ecological concepts as a basis for managing semi-tropical ranges were not accepted. In recent years practical programs have been developed combining rancher experience with range management, animal science and agronomy. These programs coordinate the use of both rangeland resources and pasture forages. The physiological requirements of the commerical cow-calf herds are likewise programmed into the yearly operation.

Implementation of a coordinated forage-herd management program that will result in a low input of fossil fuel requires planning to include (1) inventory of all available grassland resources, (2) growth processes of the major grass species, (3) cow and calf nutritional requirements and physiology and herd management as related to seasonal forage production, (4) range management and pasture conservation practices, and (5) grazing plans.

Forage inventories are recorded to include all forages available on the ranching unit. These usually include pasture species of pangolagrass (Digitaria decumbens), bahiagrasses (Paspalum spp.), and coastal bermudagrass (Cynodon dactylon var.). Major range sites include flatwoods with species of bluestems (Schizachyrium) and (Andropogon), (Paspalum) and (Panicum). Marsh range species include maidencane (Panicum hemitomon), and cutgrass (Leersia spp.).

Grazing systems are developed upon the growth cycles and nutritional values of forage species and the physiological requirements of the cow-calf herd. Controlled breeding, calving periods, supplementation and cow mending are major animal husbandry considerations as an intergal part of a combination range-pasture program. Major range management practices include brush control, namely saw palmetto (Serenoa repens), a planned deferred or rotation-deferred grazing and proper utilization of the key species.

Commerical cow-calf operations have successfully managed to achieve over 90 percent calf crops, 60-90 day breeding season and 450-475 pounds of calf per cow unit maintained. Significant reduction in amount of fossil fuel materially contributes to a low energy grassland program.

Key words: range, pasture, herd management, energy, Florida.

11-2-2 A Comparison of Native, Native-Interseeded Range and a Tame Pasture Series for Growing Beef Cattle in the Northern Great Plains

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The study's objectives were to develop the most efficient system of sustained land use for beef cattle production on native and tamed pastures with and without energy supplement. The pasture systems were: native range, native-interseeded range, native range interseeded with 2.2 kg/ha 'Travois' pasture-type alfalfa (Medicago sativa L.), and a full-season pasture series. The full-season series consisted of crested wheatgrass (Agropyron desertorum (Fisch. ex Link) Schult.),brome-alfalfa (Bromus inermis Leyss.), sudangrass (Sorghum bicolor (Linn.) Moench) and Russian wildrye (Elymus junceus Fisch.). Corn was fed on pasture at 0, 0.5 and 1.0% of body weight daily. The put-and-take system of adjusting grazing pressure with 6 tester animals and 3 replications were used. Crested wheatgrass and Russian wildrye pastures were fertilized yearly at 73 and sudangrass at 67 kg/ha nitrogen.

Substantial differences occurred between grazing seasons, 1977-1979, but the average daily gain (ADG) was significantly increased only by grain levels; no significant ADG differences between pasture treatment or pasture by grain interaction were observed during three years. No significant differences occurred between pasture by grain level interaction in grazing days/hectare, animal gain/hectare, and animal unit months (AUM)/hectare during three years.

In 1977, ADG for the 0, 0.5 and 1.0% grain level was .47, .59, and .63 kilograms, respectively. Significant differences occurred between pasture systems and grain level treatments in grazing days per hectare and animal gains per hectare. The native range, interseeded range, and tame series had, respectively, 90, 126, and 144 grazing days per hectare, and 51, 72, and 83 kilograms of animal gain per hectare.

In 1978, the ADG for the 0, 0.5, and 1.0% grain level were .59, .64, and .63 kg/day, respectively. The native range, native-interseeded range, and tame series had, respectively, 56, 97, and 97 kilograms of animal gain per hectare; and 2.20, 3.21, and 3.65 AUM per hectare. Interseeding increased animal gains per hectare 73% over native range and equaled that of the tamed series. Interseeding increased the carrying capacity 40% over native range.

In 1979, the ADG for the 0, 0.5, and 1.0% grain level were .72, .87, and .97 kg/day, respectively. At 0% grain, ADG for the native, interseeded-native, and tame series were ,66, .77, and .74 kg/day, respectively. The native, native-interseeded, and tame series had, respectively, 71, 118, and 97 kilograms of animal gain per hectare; and 1.88, 3.16, and 2.64 AUM per hectare. Interseeding increased animal gains per hectare 65 and 21% over the native range and tame series, respectively. Interseeding increased the carrying capacity 68% over the native range. At 0% grain, interseeding increased animal gains per hectare 94 and 21% over the native and tame series, respectively.

Key Words: native range, interseeded range, grazing systems, pasture-type alfalfa.

11-2-3 Summer Grazing Distribution and Behavior of Beef Cattle on Elk Winter Range

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Quantification of the relationships between cattle grazing behavior and a mosaic of range sites with varying forage quality, quantity, species composition, topography, and irregular water distribution is necessary to intensively manage foothill ranges. The study area is a Wyoming foothill range of 2,300 ha varying in elevation from 2,224m to 2,682m.

Cattle distribution data were collected with 4 to 6 radio telemetry collared animals, located once daily from June 15 to September 1 in 1979-80. At each sighting, map location, range site, activity, number of associated animals, slope gradient, distance to water and shade, and climatic conditions were recorded. In 1980, 24-hour continuous observations were made. In July, approximately 100 gm of each preferred forage species was collected from 2 representatives of each range site for nutrient analyses.

Analyses of daily observation data showed that while wetland, subirrigated and overflow range sites occupied 28% of the available land area, 63% of the observations occurred there. Mean distance from water was 550m. Average slope gradient was 5.1% and 80m long. Distance from water and slope gradient values can be attributed to the large number of observations on more mesic sites. Separating daily observations into 2-week periods and plotting animal locations indicated a dynamic distribution pattern. Initially, as a single herd, distribution is limited to a riparian zone. After 4-8 days smaller groups fragment from the main herd. These groups graze other mesic range sites with abundant forage remaining. This distribution trend continues until late August, when animals can be found on any range site, with preference still being shown for mesic sites.

Based on 15-minute interval observations, the mean grazing time from July 13-30 was 10 hours, while approximately 10 hours were spent in rumination. Watering occurred 1.4 times day^{-1}. Daily distance traveled averaged 4.2 km for steers and 3.1 km for mature cows. Average daily distance traveled for both years was 3.6 km. There was no significant difference in daily distance traveled through the season.

Forage comparisons between sites selected and not selected in 1980 indicated sites selected had significantly higher preferred forage production, forage moisture levels (increased succulence), adjusted % crude protein (CP) levels and kg of CP ha^{-1}.

Cattle on this foothill range demonstrated grazing selectivity, with respect to plant species and vegetative communities. Slope gradients (<10% for 100M) and distance from water (<660m) impose physiographic limitations on grazing distribution. These limitations may be a function of forage quantity and quality on upland sites. Results demonstrate that vegetative and physiographic characteristics on this foothill range are concomitant conditions. Sites selected have higher forage production, moisture and CP levels of palatable species ha^{-1}. Selectivity may be a function of succulence and not CP levels. Future management plans for these extensive western ranges cam be adjusted according to these results to manage these areas more efficiently.

Key words: grazing behavior, cattle distribution, range characteristics.

11-2-4 Complimentary Grazing Systems in a Semiarid Mixed Prairie Region of the Northern Great Plains

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Recommended rangeland grazing practices including delayed use in the early part of the season have not been readily accepted by producers. There was need to devise alternative grazing systems as an incentive to improved utilization.

Drought tolerant winter-hardy grasses crested wheatgrass (Agropyron desertorum F.), Russian wild ryegrass (Elymus junceus F.) and Altai wild ryegrass (Elymus angustus T.), each with alfalfa (Medicago media Pers.) are used in a complementary grazing system with native rangeland.

A cow-calf herd grazes crested wheatgrass from late April to early June at a stocking rate of 0.25 hectares/animal unit month (A.U.M.) to produce 130 kg/ha of liveweight calf gain. Native rangeland is grazed from early June to early August at a stocking rate of 1.25 ha/A.U.M. to produce 25 kg/ha of liveweight calf gain. Russian wild ryegrass is grazed from early August to early October at a stocking rate of 0.25 ha/A.U.M. to produce 110 kg/ha of gain. After this the calves are weaned and the cows graze Altai wild ryegrass until mid-December at a stocking rate of 0.27 ha/A.U.M.

We have thus concluded that the effective grazing season can be extended to nearly 9 months from that of 5 or 6 months on native rangeland only by using 40% of the land base as seeded pasture. Concurrently, this system allows for improved rangeland use and sustained range condition.

Key words: grazing, cattle, season rangeland, seeded pasture, gains, production.

11-3-1 Cattle Preference and Plant Selections Within a Hybrid Grass

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In recent years, hybrid forage grasses have been developed which show great promise for advancing grassland agriculture. These fertile hybrids have been selected for morphological, reproductive and adaptive attributes with the assumption that utility will be enhanced. Although developed as forages, only limited testing of animal acceptability and response was included in initial development. Testing animal preference and selectivity for one of these more promising hybrids was the primary purpose of the present study. Individual steers (cattle) were tamed, trained and observed for their selectivity in grazing individual plants and genetic lines of F_6 crosses between quackgrass (Agropyron repens) X bluebunch wheatgrass (Agropyron spicatum). The animals showed definite preference for individual plants within genetic lines and for different genetic lines. Different animals frequently preferred the same plant or lines with identical genetic backgrounds. Preferences were exhibited even though animals were provided access at different times or different locations to a large array of hybrid plants or given a choice between hybrids and other palatable forage species. Animal selectivity for the individual hybrid plants or for a number of plants within a genetic line was not necessarily associated with a number of measured agronomic or morphological traits. Animals preferred plants which ranked from those which were very caespitose to those that were rhizomatous. They also selected plants which had a profusion of soft leaves as well as plants with stiff erect leaves. The most significant feature was the consistency in selection for certain plants and genetic lines. Hybrid forages can be developed based solely on plant breeding criteria and human judgment but this may result in plants with reduced utility for forage except under forced utilization. Conversely, developing hybrids based entirely on animal preference may also limit utility. Plant breeding and forage use by animals need to be concurrently evaluated to assure the predetermined objective of plant improvement.

Key words: cattle preference, hybrid grass - Agropyron repens x A. spicatum, grazing preference, livestock forage, selection.

11-3-2 Relationship Between the Botanical Composition of the Herbage on Offer and Herbage Eaten by Grazing Beef Cattle

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The relationship between the botanical composition of the herbage on offer and herbage eaten is a key link in the modelling and simulation of grazing systems, yet there appear to be no data describing this relationship for multi-specific or non-temperature swards. This paper describes one such relationship for cattle grazing multi-specific swards in the sub-tropics.

Native or improved pastures were grazed by Hereford heifers fistulated at the oesophagus. The native pasture had never received fertilizer and contained mixed grasses and no legumes. One of the improved pastures consisted of native pasture fertilized with superphosphate and the other improved pastures were fertilized and oversown with white clover (Trifolium repens) on its own or in conjunction with lotononis (Lotononis bainesii).

Samples of pasture and oesophageal extrusa were collected on five occasions from June through February from two replications of each pasture. Extrusa were separated into green grass, green legume and dead herbage components. Relationships were established between the total amount of green herbage on offer (GH, tonnes dry matter/ha) and the proportion of green herbage ingested (PG, g dry matter/g total extrusa dry matter). These relationships were similar for the four pastures and were described by a single pooled Mitscherlich equation

$$PG = 0.924 - 7.901e^{-3.7006\ GH} \qquad (R = 0.93) \qquad (1)$$

with an approximate residual standard deviation (RSD) of $\pm$ 0.119.

Relationships were also fitted between the amount of green legume on offer (GL, tonnes dry matter/ha) in both of the grass-legume pastures and the proportion of green legume in the diet (PL, g dry matter/g extrusa dry matter). There were no significant differences between the relationships for the two pastures. The equation from the pooled data was linear and the intercept did not differ significantly from zero.

$$PL = 0.432\ GL \quad (SE \pm 0.070;\ RSD \pm 0.085;\ P<0.001). \qquad (2)$$

The proportion of green grass ingested (PGG, g dry matter/g extrusa dry matter) can be calculated by subtraction of PL from PG.

We are not aware of any other published relationships for multi-specific swards and we believe that our results may have wide application in modelling and simulation of cattle grazing systems.

Key words: botanical composition, herbage on offer, herbage eaten, grazing cattle.

11-3-3 Diet Selection by Cattle on Tropical Pastures in Northern Australia

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Little is known of preferential grazing of perennial tropical legumes under year-long continuous grazing. This information is required to define the role of the legume more clearly and to develop management strategies to maintain legume yields. Our objective was to study the diet selection by steers in northern Australia on a continuously grazed pasture of Setaria sphacelata var. sericea cv. Kazungula, Macroptilium atropurpureum cv. Siratro and Stylosanthes guianensis var. guianensis cv. Schofield.

The pasture was the 1.7 steers ha^{-1} treatment which gave the highest annual weight gains (154 kg $steer^{-1}$) in a stocking rate experiment. Mean annual rainfall was 1,490 mm, with 70 percent falling from December to March. Monthly temperatures are highest in December (30.1°C) and lowest (11.9°C) in July.

Pastures were sampled in 1973 (seven 3 day periods) and 1975/76 (six 3 day periods) with three oesophageal fistulated steers. Extrusa samples were analysed for nitrogen (N) and in vitro digestibility (I.V.D.) and for botanical composition by the point strike method. Pasture yields and composition were determined from cut quadrats and herbage samples were analysed for N in 1973 and N and I.V.D. in 1975/76.

In 1973 cattle selected less legume (mainly Siratro) than on offer in all months except March (12.3% compared to 8.2%). The N content of the diet was always higher than the derived value of diet components. The I.V.D. of extrusa samples exceeded 70% in five periods and was lowest (66.5%) in August 1973.

Except for December 1975, more legume (again mostly Siratro) was selected in 1975/76 than on offer, particularly in June (8.0% compared to 7.1%). Except for October 1975 the N content of the extrusa samples was greater than the derived values. The I.V.D. of the diet was highest (67.7%) in April and lowest (52.3%) in October 1975.

Seasonal variations in pasture quality were highlighted. Nitrogen and I.V.D. values illustrate the relatively low quality of tropical pastures and show the need for a high degree of diet selection to satisfy nutritional requirements. This can only be achieved under lenient stocking pressures. On pastures continuously grazed at low stocking rates, the preference by cattle for setaria over legumes during the early growing season is of practical importance in maintaining legume yields. Higher legume yields can be obtained by resting pastures at critical times. In 1973 the preference for setaria throughout the year was associated with higher cool season temperatures giving continued pasture growth.

Key words: diet selection, tropical pastures, cattle, legume, Siratro, digestibility, nitrogen.

11-3-4 Relationships Between Crude Protein, Crude Fiber and In Vitro Dry Matter Digestibility in Different Leaf/Stem Proportions in Coast-Cross No. 1 Bermuda Grass

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In January 1980 a study was conducted with different leaf/stem proportions (dry basis) of Coast-cross bermuda grass to evaluate the relationship between crude protein (CP) content and in vitro dry matter digestibility (IVDMD). Pasture was hand-sampled after a 28-day resting period and leaves and stems were separated and dried at 65°C to a constant weight. Afterwards, they were ground and mixed in the following leaf/stem proportions: 100:0; 80:20; 60:40; 40:60; 20:80 and 0:100. Also, one hand-taken sample without removing leaves from stem was used as a control. Dry matter (DM), crude protein (CP), crude fiber (CF), soluble nitrogen (SN), non-protein nitrogen (NPN) and IVDMD were determined in leaves, stem, whole plant and different leaf/stem proportions. The content (%) of soluble N from total N was 81.3, 65.2 and 76.8% for the plant, leaf and stem, respectively while the NPN content (%) of the soluble N was 31.7, 42.2 and 16.9. The IVDMD values (%) were 62.8; 57.4; 55.3; 51.3; 45.4 and 43.9 for the different leaf/stem proportions, respectively. IVDMD regression equations between CP percentage; CF percentage and CF/CP were: $Y = 20.907 + 1.832$, $r^2 = 0.92$; $Y = 128.39 - 2.66X$, $r^2 = -0.93$; and $Y = 76.31 - 13.74X$, $r^2 = -0.96$. It is concluded that as leaf/stem relationship increases, an improvement of the nutritive value of the pasture occurs.

Key words: bermuda grass, in vitro digestibility, leaf/stem ratio, crude protein, crude fiber.

11-4-1 Forage Production and Removal from Western and Crested Wheatgrass Under Grazing

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Knowledge of frequency and amount of forage removal and total forage production under grazing is essential to sound grazing management. We estimated these parameters by photographing marked crested wheatgrass (Agropyron desertorum (Fisch.) Schult.) tillers weekly during the springs of 1976 and 1977 in pastures grazed by 1.1 or 1.6 steers/ha for 6 weeks. During the summer and fall of 1976 and 1977, we photographed marked tillers of western wheatgrass (Agropyron smithii Rydb.) biweekly in native mixed prairie pastures grazed by 0.1 or 0.2 animal units/ha for 5-6 months. When we photographed the marked tillers, we photographed, clipped, and weighed unmarked tillers; these photographs served as references for estimating weights of and forage removal from marked tillers.

As stocking rate increased, frequency of grazing of tillers increased markedly, but the fraction of the available herbage removed at each grazing event increased only from western wheatgrass in 1977. In 1976, western wheatgrass tillers grazed once during the season in the lightly-stocked pasture produced significantly more forage than similar tillers in the heavily-stocked pasture. Otherwise, there were no differences in forage production between grazed and ungrazed tillers or between tillers in the lightly- and heavily-stocked pastures. In 1977, forage production of grazed tillers in the lightly-stocked pasture was greater than that of ungrazed tillers or of grazed tillers in the heavily-stocked pasture. Production per grazed tiller of crested wheatgrass was marginally less than that of ungrazed tillers, with no difference between stocking rates. Most clipping experiments have shown a much smaller decrease in production per tiller than in tiller numbers. Tiller numbers per unit area were not determined in our study.

Patterns of forage removal under grazing were markedly different from those under clipping, and removal under grazing was less severe than that imposed in many clipping studies. Properly managed grazing may be less damaging to grass growth and forage production than is often assumed. Data from our study can be used to design clipping experiments which simulate grazing more closely and provide more reliable estimates of the effects of grazing than do some earlier experiments.

Key words: western wheatgrass, Agropyron smithii Rydb., crested wheatgrass, Agropyron desertorum (Fisch.) Schult., grazing, forage production.

11-4-2

Seasonal Changes in Botanical and Chemical Composition and Digestibility of Diets of Large Herbivores on Shortgrass Prairie

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Studies were conducted during the interval of 1969 through 1974 under different seasons and grazing intensities on shortgrass prairie in northeastern Colorado to evaluate the diet of bison, cattle, sheep, and pronghorn antelope. The purpose was to determine if there were seasonal changes in the chemical and botanical composition and digestibility of the diets of these large herbivores grazing on the same rangeland.

Diets of cattle, bison, and sheep were obtained by esophageal fistula samples. Diets of the pronghorn antelope were obtained by bite-count method. Fistula forage samples were analyzed microscopically to determine botanical composition. Fistula forage samples and hand-clipped samples were analyzed chemically with results presented on an organic matter basis to correct for salivary contamination. Digestibility was determined in vitro with rumen liquor from either cattle or pronghorn antelope. Data were analyzed graphically and averaged for 28-day intervals to show typical seasonal trend in the diets of these four large herbivores. Data are presented for important plant species and functional groups.

Warm-season grass components were higher in the diets of bison at all seasons than in the diets of pronghorn, cattle, and sheep. Shrubs contribute a greater portion of the diet of sheep than of the diets of bison at all seasons and for diets of cattle and pronghorn except in the autumn. Generally, sheep diets resemble diets of cattle more closely than the diets of pronghorn antelope. The greatest difference in diets generally was between pronghorn antelope and bison. Animals generally selected a diet higher in crude protein content than the overall available herbage, but selected considerably higher crude protein content diets in the summer season than in the winter. Averaged over all animal species, dry matter digestibility of diets did not vary greatly during the year but was somewhat higher in late spring and early summer than in other seasons. As rangelands are grazed more intensively in the future, there will be more emphasis on using several herbivore species to maximize use of the vegetation. Present data are useful in providing information on which to make decisions about optimal allocation of forage to different herbivore species.

Key words: diet evaluation, seasonal trends, dietary botanical composition, dietary chemical composition, digestibility, large herbivores.

11-4-3 Nutritive Value of Cattle Diets on Fertilized and Unfertilized Blue Grama Rangeland

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Low levels of nitrogen (N) fertilization can substantially increase forage production on native rangeland providing adequate precipitation is available. Objectives of this study were to compare nutritive value of diets selected by Hereford steers grazing unfertilized and N-fertilized (45 kg N/ha) rangeland in southcentral New Mexico, U.S.A.

The study area consisted of two adjacent pastures of approximately 60 ha each, both containing comparable areas of bottomland, upland and hillside sites. Yearlong stocking rates were 4.8 and 2.4 ha per yearling steer for the control and N-fertilized pastures, respectively.

Dietary samples were collected from esophageally fistulated steers (average weight, 308 kg) during the early, mid and late periods of two growing seasons and one dormant season. Sampling periods consisted of four consecutive days using four steers per pasture. Grazed samples were analyzed for organic matter (OM), crude protein, fiber and in vitro OM digestibility (IVOMD).

Nutritive value of grazed forage from both pastures followed seasonal trends, i.e., protein and IVOMD decreased while fiber increased with advancing plant maturity. During the growing seasons protein levels were higher ($P<.05$) in diets from the fertilized pasture than in those from the control pasture with differences ranging from about 4 to 12%. Fiber values were usually about 4% higher in diets from the control pasture than in those from the fertilized pasture. IVOMD values favored the fertilized during the latter part of the first growing season by 7 to 12% ($P<.05$) but during mid to late dormancy digestibility was higher ($P<.05$) on unfertilized range.

Increased nutritive value of rangeland forage selected by grazing cattle during the growing season which was attributed to N-fertilization did not carry through dormancy. In order to benefit most in terms of increased beef production on N-fertilized native ranges, such areas could be utilized during the growing season, thus relieving grazing pressure on unfertilized range until dormancy. Seasonal cattle gains recorded over a period of years on these pastures would substantiate such a management practice.

Key words: cattle, cattle diets, nutritive value, fertilized rangeland.

11-4-4 Differences in Chemical Composition, Digestibility, and Gross Energy of Range Forage Consumed by Steers and Calves Grazing Kansas Flint Hills Range

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This project was designed to compare the differences in chemical composition, digestibility, and gross energy of range forage consumed by steers and calves grazing native tallgrass prairie in the Kansas Flint Hills area from May through September.

Eight Polled Hereford calves from spring-calving cows grazing year-long in the Kansas Flint Hills were esophageally-fistulated at about one month of age and eight esophageally-fistulated Polled Hereford steers (1 to 5 years old) were used to obtain range forage samples for chemical analysis. This study was conducted over a two-year period (1977 and 1978).

Calves with dams and steers were brought into the work area when grazing ceased the evening before collection and held until grazing resumed the next morning (Dwyer, 1961). The animals were trailered to where the herd was grazing, esophageal plugs removed, collection bags secured firmly around their necks, and allowed to graze for approximately 30 minutes. Samples were dried in a forced-air oven at 55 C until a constant weight was obtained, ground through a Wiley Mill (1 mm screen), and stored in brown bottles until analyses could be completed. Crude protein, ether extract, crude fiber, ash (AOAC, 1975), neutral detergent fiber, acid detergent fiber, acid detergent nitrogen (Goering and Van Soest, 1970), gross energy (bomb calorimetry), and *in vitro* dry matter digestibility (Tilley and Terry, 1963; modified Monson *et al.*, 1969) were determined.

Data were analyzed using a least squares analysis of variance with unequal sample size (Harvey, 1960). Standard errors for months were calculated using a mean square residual that included an interaction between year and month. Mean separation was by an approximate Fisher Behren's test with $P \leq .05$.

Calves selected a diet with a higher percentage of ether extract earlier in the growing season than did steers, and also selected a diet higher in crude protein and lower in acid detergent fiber. Later in the growing season, the neutral detergent fiber fraction of the diet selected by calves was higher than that selected by steers. The other fractions measured (acid detergent nitrogen, gross energy, ash, *in vitro* dry matter digestibility) in diets consumed by steers and calves, fluctuated as the quality of range forage changed throughout the season.

Results from this study indicate that calves and steers do not select a diet of similiar chemical quality when grazing native range forage at the same location. Calves select a higher quality diet and should be used to collect diet samples when relating chemical analysis and intake to young animals.

Key words: range forage, cattle, digestibility, chemical, composition, consumption.

11-4-5 Field Evaluation of Weight-Estimate Sampling Techniques on Rangelands

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In many grazingland studies it is important to evaluate the relative abundance of standing crop and productivity of individual plant species with regard to their productivity, digestibility, toxicity and nutrient value to grazing animals as well as their value in protecting soil from erosion. Precise estimates are needed of species biomass densities over time. Double-sampling weight-estimation botanical analysis has been evaluated in a number of field and computer studies. The present paper focuses on weight-estimation double-sampling techniques and examines the usefulness of the method under field studies in shortgrass and mixed prairie. The present studies evaluate the effect of observer variability, seasonality, plant growth form, total plot biomass relative to the selected species, and species composition influences on the precision of double-sampling procedures. Field studies were conducted over several years on shortgrass prairie in northeastern Colorado and one year on several sites in western North Dakota mixed prairie. On shortgrass prairie samples were taken in circular $0.5m^2$ plots and on mixed prairie in circular $1.0m^2$ plots. Records were compiled on time required to locate plots, time required to estimate plots, and time required to clip, dry, and weigh plots. Actual weight of green standing crop vegetation was estimated in the field and dry weights were regressed upon the estimated green weights. Simple linear regressions through the origin were used in the evaluations. Correlations between estimated and actual weights, variances of double-sampling estimates, and optimum ratios of plots estimated only versus plots estimated plus clipped were determined. Results suggest in more than 80% of the cases that variances were statistically significantly reduced by use of the weight-estimate methodolgy. Optimal sampling ratios varied widely, depending upon worker and other factors. Frequently, to maximize time efficiency about 6 plots should be estimated for each one clipped. Less gain was obtained using the weight-estimate double-sampling methods for a low-growing shortgrass species; greater gains were obtained for upright herbaceous plants such as many forbs. Weight estimation with double sampling was extremely effective for increasing precision of estimates of above-ground biomass of cactus. The effects of observer variability, seasonality, and plot species composition and yield were evaluated by analyzing correlations between actual and estimated weights. In our experience, in order to be able to detect differences between treatment means for above-ground standing crop of 10% or less will require use of extremely detailed single-sampling procedures or of well designed double-sampling approaches. The weight-estimate method requires little equipment, nominal training, and is adaptable to a wide variety of field site situations. With adequate prior preparation of data forms and calculation programs, the analysis cost is minimized.

Key words: production, rangeland, variance reduction, double-sampling, weight-estimates.

11-5-1 Top-grazing, High-Protein Forages with Lactating Ewes

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Two grazing systems, top-grazing of alfalfa (MEDICAGO *sativa* L.) and high-intensity grazing of orchardgrass (DACTYLIS *glomerata* L.) were investigated with three and four levels of concentrate respectively. The concentrates consisted of corn, oats and minerals. High dry matter alfalfa silage fed in the barn with 40% concentrate by weight was used for a positive control ration. Three or 4-day grazing periods per paddock were used with 16- and 24-day rotation cycles for orchardgrass and alfalfa respectively. Using alfalfa without concentrate resulted in mean daily yields of 20.2 kg of milk and 0.65 kg of protein. As concentrates were increased in amounts, daily milk and milk protein increased by 50%; but the proportion of edible protein for humans eaten by the cows increased from 0 to only 43% of the milk protein produced. Consequently the amount of essential amino acids returned to the human food supply in milk completely offset the amount consumed by the cows. With increasing concentrates the amount of fossil fuel used for feed production in cows grazing alfalfa rose from 1.6 megacalories (mcal) per day of herd life to 3.2 mcal. All cows grazing alfalfa were fed between 10 and 20 g of poloxalene daily which eliminated pasture bloat. Milk production was less with orchardgrass and the fossil fuel requirements for production were doubled.

The average amount of protein consumed per ha of alfalfa per season was 1.8 metric tons in 8.1 tons of dry matter.

Key words: alfalfa, MEDICAGO *sativa* L., cows, grazing, milk production, protein, human food, efficiency, bloat, concentrates.

11-5-2 Comparison of Different Numbers of Star Grass (*Cynodon nlenfuensis*,) Paddocks with Irrigation and Fertilization

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The possibility of reducing the number of paddocks with a fixed stocking rate according to the fertilization level applied was studied with dairy cows for two years. Three similar groups of twenty-two first-lactation Holstein cows were used. The stocking rate was 3.7 cows/ha. A completely randomized design with three treatments (8, 4, and 2 paddocks) was employed. Differing fertilization levels with 60% in the dry season (a total of 400 kg N/ha/year) were applied. There was a significant response in milk production favoring 8 and 4 paddocks over 2 paddocks with no difference between the two. Productions (kg/cow/day) were of 13.5, 13.4 and 12.4 for 8, 4, and 2 paddocks, respectively. The available forage and grass residues were significantly higher with 8 and 4 paddocks with no difference between them. Available forage and residue values were 3.1 and 1.9; 2.9 and 1.7; 2.2 and 0.94 t/ha for 8, 4, and 2 paddocks respectively. No differences were found in milk composition or grass quality when conventional cutting methods were used. Changes in botanical composition occurred with star grass population increasing and weeds diminishing in all treatments. It is concluded that the number of paddocks can be reduced from 8 to 4 without affecting the animal's performance and the quality of grass, allowing great savings.

Key words: *Cynodon nlenfuensis*, number of paddocks, milk production.

11-5-3 Milk Production from Silage

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Milk production systems in the U.K. with autumn calving cows depend heavily on bought-in concentrate. The objective of this work was to examine the potential of grass and legume silages for milk production.

In the first of 3 trials the primary growth of perennial ryegrass (*Lolium perenne* cv. Endura) was cut either on 23 May at 72D (HD) or on 23 June at 62D (LD) and ensiled with a mixture of formic acid and formaldehyde at 30 g HCHO/kg crude protein (CP). The silages were given *ad libitum* with a supplement of barley and soyabean meal at 6.3 kg dry matter (DM)/day to 2 groups of 12 British Friesian cows over weeks 4 to 18 of lactation. In the second trial, the primary growth of perennial ryegrass was cut either on 17 May at 68D (HD) or on 21 June at 61D (LD). The silages were prepared as in Trial 1 and given to 2 groups of 5 cows with 6.3 kg DM/day of barley and soyabean meal over weeks 4 to 18 of lactation. In addition two higher levels of the supplement (9.2 and 12.2 kg DM/day) were given with the late cut (LD) silage to 2 groups of 9 cows. In the third trial, silages were made from either red clover (*Trifolium pratense* cv. Hungaropoly) or perennial ryegrass of similar digestibility (61D) and were given *ad libitum* to 2 groups of 6 heifers from weeks 3 to 10 of lactation. From weeks 11 to 29 of lactation all heifers received the grass silage. A concentrate supplement consisting of rolled barley, ground maize and soyabean meal was given throughout the trial at 3 kg DM/day. In all the trials voluntary intake of silage and milk production were recorded daily for each animal.

In the first trial earlier cutting increased silage intake from 9.5 (LD) to 9.9 kg DM/day (HD) ($P > 0.05$) and milk yield from 24.8 (LD) to 27.9 kg/day (HD) ($P < 0.01$). In the second trial the difference in D-value of grass at cutting was less than that observed in Trial 1. However, the effect of date of cut on silage intake was greater (LD, 9.1 kg v HD, 10.6 kg DM/day, $P < 0.05$) but the response in milk production was less than that observed in Trial 1 (LD, 22.6 v HD, 24.3 kg/day, $P > 0.05$). The response to concentrate with late-cut material averaged 0.81 kg milk/kg concentrate DM with a substitution rate of 0.47 kg fall in silage DM/kg concentrate DM added. The results of the third trial showed that heifers given red clover consumed 38% more silage DM ($P < 0.001$) and yielded 13.4% more milk ($P < 0.001$) than heifers given grass silage of the same digestibility. The immediate effect of using red clover silage over weeks 3 to 10 of lactation was 150 kg of milk but the total experimental effect (weeks 3-29) was 434 kg ($P < 0.05$) or 2.9 times the immediate effect.

The data show that early cutting of herbage can produce variable responses in intake and milk yield. The maximum response obtained (c 0.3 kg milk/unit rise in D-value) could allow a considerable saving in concentrate input. The data also show the potential of using legume silage strategically within the lactation.

Key words : *Lolium perenne*, *Trifolium pratense*, silage, dairy cows, intake, milk yield.

11-5-4 Long-Term Feeding of Corn Silage as the Sole Forage in Rations of Lactating Dairy Cows

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The long-term feeding of corn silage as the sole forage to lactating dairy cows has had only limited success due to problems with production, reproduction and health after one lactation. Consequently, a long-term study was initiated in August 1975 with two groups of 19 cows, 15 two-year-old heifers and 4 three-year-old cows assigned at random to each group as they calved. One group was fed a ration with corn silage as the sole forage and the other group a ration with a 50:50 ratio of forage as corn silage and low moisture alfalfa-orchardgrass silage. Both rations contained a 60:40 ratio of forage to concentrate on a dry basis, 15% crude protein, 1.25% calcium, 0.50% phosphorus, 0.52% trace mineralized salt, 0.22% sulfur, 0.25% magnesium, and 4,400 units vitamin A, 2,200 units vitamin D, and 44 mg vitamin E/kg. The rations were blended in a mixer wagon with electronic load cells and fed once daily as a complete mix in feed bunks. All cows remained on their respective rations the entire experiment including the dry period when they were fed controlled amounts of the lactating cow ration.

When the experiment was terminated in May 1980, there were 5 cows in the corn silage group and 3 in the other group. No cows were removed the first lactation. In succeeding lactations, cows were removed from the two groups, respectively, for the following; hardware, 2 and 0; aborted 0 and 1; pneumonia 1 and 0; udder problems, 3 and 3; leg problems 3 and 2; low production 2 and 3; failure to breed, 1 and 5; other 2 and 2. There was little difficulty with digestive upsets and no problem with the fat cow syndrome. Milk production, fat tests and fat production for 305-day lactations for the corn silage and the corn silage and low moisture alfalfa-orchardgrass silage groups, respectively, were as follows: lactation I, 6,686 kg, 3.62%, 238.5 kg and 6,535 kg, 3.67%, 237.7 kg; II, 7,462 kg, 3.64%, 271.9 kg, and 6,800 kg, 3.63%, 246.8 kg; III, 8,008 kg, 3.60%, 288.3 kg, and 6,989 kg, 3.68%, 257.4 kg; IV, 8,338 kg, 3.51%, 293.1 kg, and 7,594 kg, 3.69%, 280.4 kg. The differences were not significant (P>.05), although cows on the corn silage ration tended to produce more milk and fat.

Higher than normal levels of limestone were used in these rations to reduce loss of starch in feces and to improve gastrointestinal and fecal pH. Cows in the two respective groups had average fecal pHs of 6.58 and 6.61. Calving weights of cows have been slightly higher for the corn silage group. Calf weights have been remarkably similar for the two groups. These data indicate that the long-term feeding of corn silage as the sole forage in rations of lactating cows can be successful if the rations are properly balanced and fed as complete mixed rations.

Key words: corn silage, Zea mays L., dairy cows, milk production, limestone, buffering.

11-6-1 Energy Balance Studies with Lactating Cows Fed Fresh or Frozen Grass from Pasture Suitable for Grazing

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Information on feeding value and energy utilization of the grass consumed by grazing cattle, especially lactating cows, is very limited. It is nearly impossible to perform calorimetric studies with grazing dairy cows. Similar studies indoors often show low intakes of fresh grass and require much labour. Still, in great parts of the world cattle graze at least half of the year so that knowledge of the feeding value of grass is important for practice.

In the Netherlands in 1973 and 1974, each year, 4 permanent pastures grass in the grazing stage of maturity was cut twice daily and either fed fresh, or stored at -20°C to be fed later, to 4 lactating cows in respiration chambers. Animals were adapted for 7-10 days before a collection period of 7 days on fresh grass ad lib plus 1 kg of concentrates was started. In a subsequent week the same grass in the frozen form was fed. Digestibility, N- and energy balances were measured to study energy utilization from grass.

In 1977-1979 in total 7 similar calorimetric trials were conducted with 4 lactating cows fed ad lib with grass after storage at -20°C. In some trials half of the dry matter from grass was substituted by concentrates. The grass was fed to dairy cows at the production level of feeding as well as to wethers around the maintenance feeding level. Because many feed evaluation systems use the sheep digestibility coëfficiënts of the feed as their basis it was thought wise to study the differences in digestibility between sheep and cattle.

No differences in intake, digestibility and energy utilization between fresh and frozen grass could be detected.

In the total of 83 energy balances the digestibility of grass by cattle was high (organic matter 75-83%, energy 71-78%), but varied between pastures and months. Intake depended mainly on the pasture, the composition of the grass (dm%) and/or season. Intake varied from 10.2 to 16.0 kg organic matter, but was lowest in the later trials.

Despite higher feeding levels of the cattle, cow and wether digestibilities hardly differed, except for trials with extra concentrates in the diet.

Utilization for maintenance and milk production of the metabolizable energy from grass agreed fairly well with the efficiencies found for mixed diets of conserved forage and concentrates, although some results tended to be lower.

It was concluded that grass from pastures suited for grazing is highly digestible and efficiently utilized for maintenance and milk production. Increased level of feeding caused only a minor depression of digestibility in lactating cattle. Prediction of metabolizable and net energy by the Dutch feed evaluation system seems to be satisfactory.

Key words: energy utilization, dairy cows, wethers, permanent pasture, prediction of net energy, fresh or frozen grass.

11-6-2

Utilization of Energy of Fresh Pasture by Lactating Dairy Cows

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The New Zealand dairy industry is almost totally reliant on the use of grazed herbage for the production of milk solids, but few data exist on the efficiency with which lactating cows utilize energy of fresh herbage offered as the sole diet.

One hundred and thirty two energy balances have been established by indirect calorimetry using cows at two levels of feeding and at two stages of lactation over three years. Mixed pasture suitable for grazing and cut twice daily was the sole diet. Data for the utilization and partitioning of energy has been subjected to regression analysis made on a within-cow basis.

Efficiency of utilization of ME for energy balance (milk + tissue) was higher in early lactation (spring) than in mid-lactation (autumn) (56 and 50% respectively) and at both stages of lactation was lower than that proposed by van Es (1975) (60%).

Reasons for reduced efficiency of utilization of ME were associated with higher heat increment of feed per unit intake in mid-lactation. The factors responsible included changing feed composition, a reduction in ME content of the herbage, and an increased energy cost of excretion of excess nitrogen in mid-lactation.

Key words: fresh pasture, energy utilization, lactating dairy cows.

11-6-3 Energy Requirements of Dairy Cows Grazing Pangola Grass (Digitaria decumbens Stent) in Cuba

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In Cuba during the summers of 1977 and 1978 two experiments were performed to study the utilization of pasture energy on the productive processes of the lactating dairy cow. Twelve cows were used in each experiment, divided into three groups of four animals each according to the stage of lactation: initial, medium and final. The animals grazed on a fertilized pangola grass (Digitaria decumbens Stent) without any supplementation and were under rotational grazing conditions from 4 p.m. to 4 a.m. and from 6 a.m. to 11 a.m. The following measurements were taken for each animal within a period of one month: DM intake (measured by the chromic oxide technique), fat corrected (4%) milk production (FCMP) and live weight change. Pasture samples were taken to estimate the concentration of metabolizable energy by determining the in vitro DM digestibility. Data from the two experiments were jointly analysed. Pasture had an ME concentration of 2.0 and 1.9 Mcal/kg DM in 1977 and 1978, respectively. The range of ME intake was 26 to 33 Mcal/day; metabolic weight was 93 to 113 $kg^{0.75}$; FCMP was 7 to 17 liters/day; and live weight change was -0.42 to + 0.15 kg/day. A linear inverse relationship between FCMP and live weight changes was found ($r = -0.75$; $P<0.001$). Taking this into consideration and assuming that the ME requirement for 1 liter of FCM is 1.17 Mcal (64% efficiency), a requirement of 30.8 Mcal/kg gain for fattening (20% efficiency) was calculated. From these data and considering the distribution of ME between the processes of maintenance, milk production and live weight changes according to the equation $ME = a\ (LW)^{0.75} + b\ (FCMP) + c\ (LWC)$, the maintenance requirement (a) calculated was 214 $Kcal/kg^{0.75}$. It is suggested that the lactating dairy cow fed only pangola grass under tropical conditions has a low efficiency of energy utilization for fattening and the maintenance requirement can be increased 75% of that reported for stabled animals in temperate climates.

Key words: energy requirements, grazing lactating cows, Digitaria decumbens, tropics.

11-6-4

Grass Silage Intake by Dairy Cows: Potential to Meet Maintenance and Milk Production Requirements

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We have studied the use of direct-cut grass silages for dairy cows every year since 1971. Our main objective was to measure the intake and digestibility of these silages in order to estimate their potential for meeting the requirements for maintenance and milk production.

Twelve silages were prepared by the following three techniques which considerably improve the intake compared to those used 10 - 20 years ago :

- fine chopping (1-3 cm)
- addition of formic acid as an efficient preservative (3.5 l/ton)
- covering the roughages with good quality plastic sheet to prevent oxygen from entering the silo.

Three other silages were made simultaneously with 3 of the above twelve, but without formic acid. All the roughages were directly cut and ensiled into 100 m^3 bunker silos.

All trials were carried out in winter, with silages fed ad libitum to groups of 8 - 12 cows, from the second to fifth month after calving. The amount of concentrates fed was predetermined to meet the total requirements by taking into account silage intake, its digestibility, the milk production at the beginning of the experimental period and then the predicted milk production. Elsewhere two of the 12 formic acid silages were also fed with 1 kg concentrates more and with 1 kg concentrates less. Experimental periods lasted 10-13 weeks, which allowed variations in animal liveweight to be measured.

The twelve silages with formic acid were well preserved and had a high organic matter digestibility (72.4 %). The ingested dry matter of silages and concentrates was 2.09 and 0.59 kg per 100 kg liveweight respectively, for cows producing, on the average, 19.5 kg fat-corrected milk with a daily liveweight gain of 126 g. When no formic acid was used silage intake considerably decreased (- 12.6 %), partly due to a higher distribution of concentrates. Indeed, for the two silage fed with different level of concentrates, dry matter dropped 0.5 kg when a 1 kg dry matter increase in concentrates was made.

The net energy provided by the fine-chopped formic acid preserved silages was enough to cover maintenance needs and a mean production of 12 kg of milk per adult cow (from 5 kg for late-cut to 17 kg for very early-cut). For 5 silages of perennial rye-grass at first growth this milk production potential was 15 kg for an organic matter digestibility of 74.7 %. Milk potential decreased by about 2 kg when silages without formic acid were given and had to be compensated for by concentrates.

So, if grass silages are perfectly prepared at an early stage of growth, their feeding value can be very high. Moreover, these grass silages generally can "sustain" the same level of milk production with nitrogen as with net energy.

Key words : grass silage, feeding value, dairy cows.

11-7-1 Effect of Supplements on Live-Weight Gain of Beef Cattle Given Forage During the Dry Season

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The low quality of standing pasture grasses in the dry seasons presents a major problem in the intensification of beef production in the tropics. The objective of the research was to examine the role of maize and grass silage or standing Napier grass (Pennisetum purpureum) as sources of forage when given alone or with supplements to beef cattle.

In the first of 3 trials conducted at the National Agricultural Research Station, Kitale, Kenya, 36 Friesian castrates, initially 249 kg live weight (LW) were given silage of whole-crop maize either alone or supplemented with corn-and-cob meal. Each of these two basal diets was given ad libitum without a nitrogen (N) supplement or with urea or cotton seed cake. In the second trial 17 Friesian steers, initially 158 kg LW, and 17 Hereford steers, initially 177 kg LW, grazed a Napier grass (P. purpureum cv. French Cameroon) pasture throughout the dry season. The steers either received no supplement or concentrate at either 5 or 10 g/kg LW per day. In the third trial 25 Friesian steers, initially 161 kg LW, were given silage of Rhodes grass (Chloris gayana cv. Mbarara) ad libitum either alone or with concentrate at 0, 20, 40, 60 and 80% of total dry matter (DM) intake. In the final two trials the subsequent performance of steers during the wet season was examined.

In the first trial the level of performance of steers given maize silage alone was not significantly different from maintenance. Supplementation with both corn-and-cob meal and N significantly ($P < 0.001$) increased LW gain to a mean of 1.25 kg/day. In the second trial the LW gain of steers grazing Napier grass was 0.35 kg/day and this was increased to 0.70 kg/day ($P < 0.001$) when the animals were given concentrate at 10 g/kg LW. In the third trial steers given grass silage alone grew at only 0.10 kg/day. Supplementation of the silage increased LW gain up to a maximum of 1.40 kg/day when the concentrate comprised 80% of total DM intake. Examination of subsequent performance at grass in Trials 2 and 3 showed that cattle given forage alone during the dry season grew significantly faster than those which had received concentrate. Further, the results of Trial 3 showed that the marked differences in LW apparent at turnout were considerably narrowed by the end of the grazing season and also that there was no significant effect of previous dry season treatment on LW at slaughter or carcass weight.

The results show that supplementation of forage with energy and/or nitrogen is required for high levels of LW gain during the dry season. However, in pasture based systems in the tropics the need for such high levels of performance is questionable when compensatory growth can be exploited in a subsequent grazing season.

Key words : maize (zea mays), pennisetum purpureum, chloris gayana, silage, beef cattle, intake, live-weight gain, carcass weight.

II-7-2 Effects of Feeding Level and Forage-to-Concentrate Ratio on the Digestibility of Pelleted Diets by Sheep and Cattle

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Sheep are frequently used to determine the nutritive value of cattle feeds. However, there is some evidence that digestion coefficients for cattle and sheep may differ and that digestibility may be influenced by the level of feeding. The purpose of this study was to investigate the effects of feeding level and animal species on the digestibility of pelleted diets containing different ratios of alfalfa hay to barley grain.

Five 40-kg yearling crossbred lambs and four 350-kg yearling steers were used to evaluate each diet. Apparent digestibility was determined by the total fecal collection method. The six diets were isonitrogenous and contained the following proportions of barley grain and alfalfa hay (percent as fed basis): (1) 0, 98,0; (2) 18.0, 80.1; (3) 56.0, 62.0; (4) 54.0, 44.1; (5) 72.0, 25.6; (6) 90.0, 6.7. The barley and alfalfa were ground through a .64 cm screen and the complete feed was pelleted (1.59 cm diameter). Animals were fed twice daily at 0830 and 1630 hours. Feed intakes were 50, 75 and 100 $g/W^{.75}$. Sheep offered 100 $g/W^{.75}$ of the three high barley diets were at approximately *ad libitum* levels of intake.

Average digestion coefficients for organic matter (OMD), crude protein (CPD) and acid detergent fiber (ADFD) in the six diets were lower ($P < .05$) with sheep than with cattle: 70.4 vs 71.8, 71.2 vs 73.4 and 31.9 vs 35.1, respectively. Increasing feed intake from 50 to 100 $g/W^{.75}$ reduced ($P < .05$) OMD and CPD, but did not affect the digestibility of ADF. OMD and CPD increased by .25 and .11 percentage units, respectively, for each percent increase of barley in the feed for OMD values ranging from 59.9 to 81.2% with sheep and from 61.0 to 83.3% with cattle.

The results of this investigation show that while digestion coefficients of the pelleted diets were significantly higher in cattle than in sheep, differences were not large. For routine feed evaluation the digestibility by cattle of pelleted feeds consisting of grain and hay may be estimated from values obtained with sheep, provided that relative feeding levels are similar.

Key words: barley:alfalfa ratio, intake level, digestibility, sheep, cattle.

11-7-3 Simulation of Complementary Forage Cropping by Feeding Oat Grain to Ewes

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In many parts of the world where year-round grazing is feasible, complementary forages such as oats or sorghum are sown to improve the quantity and quality of the forage available at specific periods. Experiments in which these crops complement well-fertilized grassland have generally not shown an increase in animal production compared with all-grassland systems. The present experiment aimed to determine the effects of a simulated complementary forage crop on pasture yield and on the production of breeding ewes.

Eight groups of 10 sheep grazed 0.6 ha plots of Phalaris aquatica L.-Trifolium repens L. and eight groups of 10 grazed 0.8 ha plots. To break the nexus between pasture and crop growth rates the provision of a complementary forage crop was simulated by giving the ewes a ration of 250 g/ewe/d oat grain of ca 70% organic matter digestibility, equivalent to almost half their basic maintenance requirement. It was supplied for seven-week periods at mating, during lambing, on both occasions, or not at all. The four treatments were replicated twice at each stocking rate. To simulate the effects of withdrawing part of a farm from grazing to grow a complementary forage, stocking rates were increased by 10% for some weeks before each feeding period. Fine-wool Merino ewes were used for four years, then crossbred ewes mated with Dorset rams for two years.

The treatments did not significantly affect forage available, wool production, reproductive performance of the ewes or the weaning weight of their lambs. There were no interactions with stocking rate even in an abnormally dry year or with the high twinning rates of the last two years, although production per animal was generally lower at the higher stocking rate.

The experiment is considered in relation to other published comparisons. The importance of ensuring that the quantity and quality of the complement is consistently and materially superior to the pasture it replaces is discussed, with means of achieving this.

Key words: complementary forage system, oats, supplement, ewes, lambs, wool.

11-7-4 Effect of Maturity and Associative Effects on Corn Stalk Utilization

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Cornstalks are an important forage resource for the winter feeding of beef cows and calves. Small quality changes are very important to animal performance. Cornstalks were hand harvested at physiological maturity (PM) and weekly thereafter for 8-10 weeks during 1976, 1977, 1978 and 1979. In vitro digestibility decreased linearly with time. Intercepts (digestion at PM) and slopes (% decline in dig./wk) were 63.2, 66.3, 53.4, and 1.95, 2.04, 1.30, respectively for the firs. 3 years. Seven full season varieties were sampled in 1979. Similar changes with time were observed. Variety and moisture (irrigated vs dryland) affected stalk quality but plant population did not. Grain yield was influenced by all three but was not related to stalk quality. Cell wall content was highly related to in vitro digestibility (r=-.88). A lamb digestion trial was conducted to compare earlage (high moisture ear corn), corn silage, stalklage harvested at PM, 35 days post PM and 63 days post PM. Dry matter digestibilities were 73.9, 67.4, 61.9, 53.0 and 36.9%, respectively. Early harvested stalks were nearly as digestible as corn silage. Stalks harvested at 40 days post PM had higher dry matter digestibility, fiber digestibility and rates of particulate and liquid passage from the rumen than stalks harvested 70 days post PM. Digestibility and rate of passage trials were conducted with sheep to determine the associative effects of corn grain and cornstalks at ad libitum intake. Treatments, ratio of supplemented grain to supplemented stalks were: A, 0:100; B, 25:75; C, 50:50; D, 75:25; E, 100:0. The regression of intake on dry matter digestibility (DMD) of corn grain was 94.8 -.161lx (r=-.88). Using these DMD for the corn, the expected ration DMD could be calculated. Treatment, actual DMD and percent of expected DMD actually achieved were: A, 53.4, 100; B, 57.2, 90.2; C, 64.4, 90.6; D, 70.9, 90.2; E, 814, 100. Polyethylene glycol, chromium oxide and mordanted fiber disappearance (%/hr) were: A, 12.7, 2.1, 1.8; B, 10.6, 2.6, 3.0; C, 17.3, 3.3, 3.3; D, 12.5, 3.5, 3.4; E, 5.15, 3.1, 1.5. Rumen pH was lower as increasing amounts of grain were fed. The decreased pH coupled with a more rapid rate of passage may have led to the decreased DMD and NDF digestibility. Two steer growth trials were conducted to compare the feeding value of corn silage with stalklage harvested at high moisture grain harvest (35 days post PM) and that harvested after dry corn harvest (60 days post PM). In both trials, steers fed corn silage gained faster and more efficiently than those fed stalklage. Steers fed the early harvested stalklage gained .17 kg per day more (.65 vs .48) and were 19% more efficient than those fed late harvested stalklage.

Key words: cornstalks, residues, quality, maturity, cattle.

11-8-1 Increasing Productivity and Extending Grazing Season of Cynodon Pastures for Steers with N and Overseedings of Trifolium and Festuca in the Southeast U.S.A.

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A series of grazing experiments has been conducted 80 km east of Memphis, TN since 1969 on fine-silty, mixed, thermic, Typic Hapludalfs to evaluate productivity and quality of *Cynodon* pastures grown with N fertilizer or in combination with *Festuca arundinacea* and/or 'ladino' *Trifolium repens*, sometimes with *T. pratense*, for growing beef steers. Pastures were grazed by the put-and-take system, and forage growth and consumption were determined by the cage-and-strip method.

'Midland' bermudagrass (*C. dactylon*) grown at 4 levels of N fertilization (0, 112, 224, 448 kg/ha) was compared (1971-73) to common (*C. dactylon* var. *dactylon*) fertilized with 112 kg N/ha and to a mixture of orchardgrass (*Dactylis glomerata*) + ladino clover (OG-Lad) fertilized with P and K only. Forage production and animal performance were different in all treatments for spring (April-June) and for summer (July-September). Grazing season length was not affected by N. Forage production of OG-Lad was twice as large in spring as in summer. Animal grazing days/ha for the season ranged from 546 on Midland-0 to 1,759 on Midland-448 pastures. Total beef production was 161, 282, 354, 604, 308, and 561 kg/ha from Midland-0, -112, -224, -448, Common-112, and OG-Lad pastures for the entire season, respectively. These values were associated with average gains of 355, 420, 395, 445, 500, and 850 g/steer/day and estimated forage dry matter (DM) intakes of 8.2, 8.9, 6.0, 5.7, 8.1, and 8.7 kg/steer/day, respectively.

In the second 3-year cycle (1975-77) total beef production was 389, 391, 520, 310, 377, 310, and 341 kg/ha from 1.2 ha of Midland + ladino + red clover (*T. pratense*); Midland-224; Midland + fescue in 25-cm rows + 291 kg N/ha; Fescue + ladino & red clovers (Fes-Leg); OG-Lad; Common-224; and from 0.8 ha of Fes-Leg + 0.4 ha of Midland-224, respectively. These values were concomitant with average gains of 575, 520, 480, 525, 795, 510, and 515 g/steer/day and estimated forage DM intakes of 7.2, 5.4, 6.5, 5.4, 7.0, 6.2, and 5.6 kg/steer/day, respectively.

In the third cycle (1979-present) fescue established in 25- or 50-cm rows in Midland with clovers survived well. Total beef production/ha/yr from these stands was less than that from OG-Lad mixtures grazed until August or from Fes-Leg mixtures grazed from spring through fall. Daily gains were: Midland-Fescue-Leg, 650 g, and with N, 470 g; Fes-Leg, 690 g; OG-Lad, 840 g. Steers grazing 2/3 as much Fes-Leg area with 1/3 extra area as forage *Sorghum* in summer and *Secale cereale+ Lolium multiflorum* in winter gained 720 g/day.

These experiments have shown that bermudagrass pastures can support many young beef animals for 5 months/year if fertilized with N; can produce rapid gains in spring if legumes are present; and can provide grazing for 9 to 10 months/year if overseeded with fescue and/or legumes. Combinations of bermudagrass, fescue and clovers can be maintained for several years and can result in satisfactory beef production of over 450 kg/ha/year.

Key words: tall fescue, orchardgrass, midland bermudagrass, ladino clover, forage intake, beef production, humid mesothermal.

11-8-2

Feeding Value of the Legume Component Pasture and Silage

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Grazing experiments were conducted to examine the feeding value of various pastures for grazing sheep. Most recently the use of legumes for improving the growth of weaned lambs during the dry summer-early autumn, was investigated at Hamilton, Victoria.

The fleece weights of weaner sheep grazed on eight pasture mixtures of varying grass-species, increased as the amount of clover in the pasture increased (r = 0.88**). In a separate study, young sheep gave greater rates of growth on lucerne-grass pasture than on grass-subterranean clover pasture. Most recently the liveweight gain of 4-month-old lambs grazing legume pastures during 3 dry months in summer-autumn was 9.5, 9.4, 8.9 and 8.7 kg on red clover, giant shaftal clover *(T. resupinatum)*, lucerne and white clover pasture, respectively. These gains were greater than those obtained on perennial ryegrass-subterranean clover pasture (0.4 kg) or cocksfoot-subterranean clover pasture (2.2 kg).

Store lambs offered unchopped wilted silage for 8 weeks had higher intakes of grass-red clover silage than of grass silage. Carcass gain was 0.35 and 0.16 kg/week respectively. Carcass gain/unit digestible dry matter consumed was higher for the grass/red clover silage than for the grass silage. The mean retention time of dry matter in the reticulo-rumen was 19% shorter with the grass/clover silage.

Superior animal performance on legume dominant pasture occurred, sometimes despite a higher dry matter production from grass dominant pasture. Producers should aim to provide a minimum of at least 30% legume in sheep pastures in south-eastern Australia, especially in the dry summer when the feeding value of grass falls rapidly. Plant improvement should aim at providing perennial legumes suitable for all the main soil/climate environments.

Key words: silage, nitrogen fertilizer, lucerne, red clover, white clover, *Trifolium resupinatum*, *T. subterraneum*.

11-8-3 Summer Annuals and Improved Permanent Pasture as Forage for Growing Weaned Lambs

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West Virginia sheep producers have difficulty producing lambs suitable for slaughter without the use of grain. Lambs are commonly grazed with ewes, but the quality and quantity of forage during July and August restrict lamb growth. The objective of this study was to determine the suitability of using summer annuals and improved permanent pasture for growing weaned lambs.

Replicated permanent pasture plots, 0.25 ha each, were treated in 1979 with 100 kg nitrogen (N)/ha, lime, phosphorus (P), and potassium (K) according to soil test, sprayed with paraquat (1,1'-dimethyl-4,4'-bipyridinium dichloride), and sod seeded to Tifleaf pearl millet (Pennisentum typhoides 'Burm' Stapf and C. E. Hubb.); Sudax FFR-66, a sorghum-sudangrass hybrid (Sorghum cross); and Svalof's Sirius forage turnips (Brassica campestris L.). Permanent pasture was treated with lime, P, and K but not N and used as a control. Pastures were managed to favor seeded species, or Trifolium species in the case of the permanent pasture. The sorghum-sudangrass was rotationally grazed. All other plots were continuously grazed using ten lambs/plot assigned randomly within sex and weight. Grazing pressure was controlled using additional lambs in a put-and-take system. The permanent pasture and the sorghum-sudangrass provided significantly more (Duncans Multiple Range Test 5% level) lamb grazing days (737 and 746) than either millet or turnips (562 and 546). Average daily gains/lamb were 0.15 kg on permanent pasture, 0.17 kg on millet, and 0.16 kg on turnips, all of which were significantly higher than gains on the sorghum-sudangrass (0.04 kg).

Grazing trials were repeated in 1980. Millet and the sorghum-sudangrass were deleted and turnips seeded in their place and managed using a rotational grazing system. Average daily gains/lamb in 1980 were 0.14 kg on turnips grazed rotationally, 0.15 kg on turnips grazed continuously, and 0.16 kg on permanent pasture. There were 312 lamb-grazing days on turnips grazed continuously, 322 days on permanent pastures, and 355 days on turnips grazed rotationally. The higher number of grazing days in 1979 was a result of weather conditions which allowed grazing to continue a month longer in 1979 than in 1980.

Lambs gained as fast or faster on improved permanent pasture as on sod seeded annuals. Permanent pasture provided as many lamb-grazing days as other species. Permanent pasture was the earliest pasture available for grazing and provided grazing later in the season than annuals. Turnips provided an abundance of forage for short periods and resulted in the same lamb performance when grazed continuously or rotationally. Apparently the forage needs of lambs can be met more efficiently under growing conditions typical of the higher elevations in the Appalachian Mountains by concentrating on permanent pasture management rather than by introducing summer annuals. If summer annuals are used to complement permanent pastures, turnips would appear to be a better choice than millet or sorghum-sudangrass.

Key words: permanent pasture, millet, turnips, sorghum-sudangrass, sheep, average daily gain, carrying capacity.

11-8-4 Initial Rate of Digestion and Legume Pasture Bloat

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This report summarizes a series of studies in which the overall purpose was to provide the basic knowledge for breeding a bloat-safe alfalfa cultivar. Two working hypotheses of pasture bloat were tested. The cell rupture theory proposes that leaf mesophyll cell rupture is an important event in the occurrence of pasture bloat. The initial rate of digestion (IRD) theory proposes that susceptibility to rapid initial digestion by ruminal bacteria is a characteristic of bloat-causing forages.

The experimental studies involved extensive comparisons of bloat-causing legumes and bloat-safe legumes: alfalfa (*Medicago sativa* L.), red clover (*Trifolium pratense* L.), white clover (*Trifolium repens* L.), arrowleaf clover (*Trifolium vesiculosum* Savi), birdsfoot trefoil (*Lotus corniculatus* L.), cicer milkvetch (*Astragalus cicer* L.), and sainfoin (*Onobrychis viciifolia* Scop.). IRD was measured *in vitro*, and with the nylon bag technique in rumen-fistulated sheep or cattle. Daily bloat incidence and rumen fluid composition were recorded in rumen-fistulated cattle fed fresh alfalfa.

Bloat-causing legumes were digested more rapidly than bloat-safe legumes. The concentrations of plant cell contents in rumen fluid of sheep fed alfalfa were higher than in sheep fed three bloat-safe legumes. Daily measurements of IRD by the nylon bag technique were moderately correlated with daily bloat incidence and the concentration of chlorophyll in rumen fluid was higher for bloated cattle than for non-bloated cattle.

From a comparison of the legume species, events which affect IRD are: (1) mechanical disruption prior to microbial digestion, (2) bacterial colonization and invasion of plant tissues, (3) maceration of plant tissues by pectinolytic enzymes, and (4) disruption of plant cell walls. Differences between bloat-causing and bloat-safe legumes have been identified in the first three of these events, but at this level of comparison each of the bloat-safe legumes has different characteristics.

These studies have provided the basis for breeding a bloat-safe alfalfa cultivar by selecting for low IRD.

Key words: digestion, pasture, bloat, alfalfa, birdsfoot trefoil, sainfoin, cicer milkvetch, arrowleaf clover, red clover, white clover.

11-8-5 Beef Production on Natural Grassland with Tropical Legumes by Means of a Deferred Grazing System

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A four-hectares lot covered with spontaneous grasses (Paspalum notatum and Dichanthium annulatum) was divided into four similar paddocks, sowing the legumes Glycine wightii and Macroptilium atropurpureus in two of them, in rows two meters apart. Once the legumes were established, a total of 10 crossbred yearling steers (3/4 Holstein x 1/4 Brahman) of 173 kg of initial liveweight were assigned to graze the area, being limited to the two paddocks with grasses alone during the wet season but grazing the four paddocks during the dry season. This deferred grazing system was compared with another consisting only of the two mentioned grasses at a stocking rate of 2.5 beasts per hectare. During the wet season of this 22-month experiment liveweight daily gains did not differ between the two groups (303 vs 338 g/day/head) but during the dry season the animals of the legumes system gained 108 g/day and the animals on grasses only gained 60 g/day. At the end of the second year of evaluation, the animals were replaced by other ones of different breeding (7/8 Holstein x 1/8 Brahman) but similar initial liveweight. Stocking rate was reduced to 2 beasts/ha for both treatments and also including another treatment consisting of supplementation with torula yeast at a rate of 200 g/head to animals grazing the same species of grasses at the same stocking rate. During the 15 months of this second experimental period the animals of the deferred legume system gained 320 g/day while the groups on grasses only and on grasses with protein supplement gained 240 and 250 g/head/day, respectively. Pasture availability of DM in the paddocks with legumes at the time of introduction of the animals was above 2.5 t/ha during the dry season while in the paddocks with grasses alone it ranged from 1.5 t/ha at the beginning of the season to less than 1.0 t/ha at the end. During the dry season of the fourth year of evaluation the rate of legume ranged from 75 to 90 percent for both paddocks of the deferred grazing system. A spontaneous legume, Indigofera mucronata, appeared in rate similar to G. wightii and M. athropurpureus at the beginning of the dry season while at its end only G. wightii appeared in the samples. The results suggest that the deferred grazing system is an adequate way to guarantee the permanency of the legumes for improving animal production and for stabilization of increases in animal liveweight during both seasons.

Key words: natural grassland, beef production, tropical legumes.

11-9-1 Studies on the Nutrient Composition and Feeding Value of Dystaenia takesimana (Nakai) Kitakawa for Ruminants

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Dystaenia takesimana (Nakai) Kitakawa grew natively on a damp area of Wooleung Island of Korea. Studies were carried out in order to determine the chemical composition at various maturities and nutritive value of Dystaenia takesimana for ruminants.

Three groups of lactating Holstein cows and growing Korean native calves were used in feeding experiments with Dystaenia takesimana in three different physical forms, fresh, dried powder, and silage.

As the plant matures, crude protein (CP) and phosphorus (P) were decreased while crude fiber and calcium (Ca) level increased. The amino acid composition was similar to that of wheat bran. However, neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose, and hemicellulose levels were significantly lower than those of alfalfa and orchardgrass. Dry matter (DM) digestibility was higher than that of orchardgrass, but similar to wheat. The average levels, in Dystaenia takesimana, of CP, Ca, P, NDF, ADF, cellulose and lignin were, on a DM basis, 18% , 1.0%, 0.3%, 19.8%, 19.0%, 12.9%, and 5.7%, respectively. Total digestible nutrient content was about 60%.

When fresh Dystaenia takesimana was fed to lactating Holstein cows along with orchardgrass at three different ratios (25:75, 50:50, and 75:25), milk production and feed intake did not vary significantly. However, fat content per unit amount of milk seemed to be lowered as the the proportions in total fresh grasses increased. When the lactating cows were fed Dystaenia takesimana in silage form, the milk production and silage intake per day were increased when compared to other group of cows fed corn silage (17.9 kg vs. 16.8 kg and 30.3 kg vs. 25.0 kg). On the other hand, the powdered form could be substituted for wheat bran, up to 40%, without any adverse effects on milk production and feed intake.

When fresh form was fed ad libitum to Korean growing calves, concentrate level of 0.5% of body weight was recommended (as compared with 0, 1.0, and 2.0%) to be the most profitable and to result in the highest daily weight gains. Dystaenia takesimana silage is recommended to be fed to growing Korean native calves at ratios of concentrate to silage ranging from 6-5:4-5. Powdered form is recommended to substitute at levels no higher than 20% of wheat bran for the growing calves.

In conclusion, Dystaenia takesimana was shown to be significantly low in cell wall contents and high in digestible nutrients. It is a good forage source, either in fresh or silage form, for ruminants. It also may be substituted for 20-40% of the wheat bran in concentrates for ruminants when it is in powder form.

Key words: Dystaenia takesimana, silage, dry powder, fresh form, lactating cows, calves.

11-9-2 The Potential of Forage Produced from Cassava (*Manihot esculenta* Grantz) as a Protein Source for Cattle

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The tropical plant cassava (*Manihot esculenta* Grantz) is used widely as an energy source in animal feeds, while relatively little use has been made for this purpose of the aerial part of the plant, which is rich in protein. An experiment was conducted in the Cauca Valley of Colombia to study the possibility of feeding cassava forage preserved as silage to beef cattle. The cassava stakes were planted in beds on a 30 cm square grid to give a population of approximately 95,000 plants/ha. Six plots each of 0.1 ha were planted. One plot was harvested every 15 days, in rotation, permitting 90 days regrowth between each cutting. At harvest the forage was cut at a height of 10 cm above the ground, sun dried for 6 hours, put through a forage chopper and blown into an upright silo. At 90 days growth the aerial part of the cassava plant was 49% leaf, 15% stem and 36% stalk with a protein content of 35, 12, and 13% respectively. The entire aerial part of the plant contained 18.6% dry matter (DM) and 25.5% protein, over half of which was contained in the leaves. Total dry matter production calculated from two cuttings in 180 days was 16.3 t DM/ha/yr and 4.0 tons/ha/yr of protein. Six five-month-old weaned zebu calves were assigned according to weight to each of the following treatments: (a) cassava silage *ad libitum*; (b) cassava silage *ad libitum* plus 0.5 kg of cassava root meal; (c) cassava silage *ad libitum* plus 0.5 kg of cassava root meal plus 0.25 kg of cotton seed meal (CSM). The calves, which averaged 98.0 kg at the beginning of the experiment, were stall-fed individually. A gain of 254 g/day was achieved on cassava silage alone while the addition of 0.5 kg of cassava root meal increased daily gain by 60% (405 g/day) ($P<.01$); the addition of 0.25 kg of CSM improved gains still further (472 g/day) but these were not significantly greater than in treatment B ($P<.05$). While the amount of cassava silage eaten by animals in the three treatments was similar (1.90 kg/ha/day), the efficiency of feed conversion in treatment A (7.89) was inferior ($P<.05$) to that in treatments B (5.87) and C (5.27), which were not significantly different. No toxicity symptons were observed during a 112 day feeding trial, which suggests that if toxic levels of hydrocyanic acid existed in the fresh forage, it was eliminated by the ensiling process. Cassava forage silage appears to provide a good source of protein for ruminants, but the silage alone does not contain sufficient energy for maximum protein utilization and should be supplemented with an energy concentrate, e.g. cassava root meal. The high moisture content of the silage limited nutrient intake, which is a known disadvantage of any silage versus a dry method of conservation. The results suggest that cassava forage can be successfully used as a protein source and that the entire cassava plant could be used to provide most of dietary needs of ruminants in tropical areas where other more traditional feeds are not available.

Key words: cassava, *Manihot esculenta* Grantz, forage, protein, cattle.

11-9-3 Effect of Cutting Stage on the Nutritive Value of Four Oat Varieties Grown Under Tunisian Conditions

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Four oat varieties (Avon, crin noire, crème and Tam 312) were studied to determine Har nutritive value and the optimum cutting stage for green fodder and silage making. All four varieties were seeded in the fall of 1979 at a rate of 80 kg/ha in the northern part of Tunisia under rainfall conditions of 600 mm. They all received 67.5 units of phosphorus (P_2O_5) and 60 units of nitrogen (N).

Forage samples were collected, starting with the flag leaf and at weekly intervals thereafter until the heads reached the hard dough stage of maturity. Samples of the green material were taken for moisture determination. Some of the plant material was then dried and the plant tissue was analyzed for protein, ether extract CF and ash content.

Silage was made from each sample in 2-liter hermetically sealed containers. These silages were then analyzed for DM, CF, N, and ash content. Silage quality was determined on the basis of pH and VFA. Digestibility of both green forage and silage samples was determined both in vitro and in situ.

Increased DM content with advanced maturity was significantly higher for the crin noire variety, 40% vs. 29.5% for the Avon variety. Tam 312 showed a higher nitrogen content (P=.05) than all the other varieties and this up to milk stage. At the dough stage Avon had a slightly higher nitrogen content. Data of both in vitro and in situ studies indicated that Tam 312 has a better digestibility (P=.05) than the three other varieties and this at all stages of maturity. Mean digestibility values of OM for the green fresh material were 73% at the boot stage and 65% for the dough stage. Tam 312 showed more regular drop in DOM content with advanced maturity. Results of this study indicated that the optimum stages for silage making were bloom to milk stage, early milk stage, late milk stage and bloom stage for crème, crin noire, and Tam 312, respectively.

Key words: oat, nutritive value, silage quality.

11-9-4

Using Crabgrass as a Forage

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Crabgrass (Digitaria sanguinalis) has proven to be an excellent forage in research and demonstration work in Oklahoma. Crabgrass has been utilized for decades in a somewhat accidental fashion, but now is planned-for forage. By employing proper management inputs crabgrass can be managed as an annually perpetual planned volunteer pasture equal to or surpassing the perpetuity of adapted perennial grasses. One double crop small grains-crabgrass pasture has been successful on the same field nine consecutive years.

Management inputs include: (1) production on an acceptable soil type and locale; (2) proper development of natural or planted stands; (3) acceptable annual tillage practices that are absolutely necessary; (4) adequate nutrition with nitrogen (N) and phosphorus (P); (5) weed control; (6) acceptable haying and grazing practices; and (7) use of good natural selections.

Research has shown nitrogen responses of up to 35 kg of forage per kg of N. Tillage, to destroy remnants of the old crop and effect seedbed preparation and planting of the next planned volunteer crop is absolutely necessary for good forage yields and persistence. Tillage treatments have yielded up to 182% of no-tillage treatments at the same N level with greater differences early in the season. Selections have proven vastly different. Three selections that showed superior forage traits to other selections have been chosen for possible seed increase.

Results of research studies illustrate potential pasture yields. Yields have averaged 6 to 9 metric T/ha with the highest yield recorded at 14.3 metric T/ha. Studies have recorded seed yields up to 647 kg/ha, but that is a fraction of seed produced.

Demonstrations have shown beef cattle stocker calf gains to average .67 kg/day with ranges from .35 kg/day on mature grass to .93 kg/day on younger, lush pasture. The highest daily gain recorded has been 1.30 kg/day.

Forage quality has varied from a low of 5.4% crude protein (CP) for mature forage to a high of 27.0% CP for young lush pasture. Digestible dry matter (DDM) has ranged from a low of 36.7% DDM for mature forage to a high of 79.8% DDM for young lush pasture.

Key words: crabgrass (Digitaria sanguinalis), forage, management, fertilization, pastures, double cropping, yields, quality.

11-10-1 Role of Alkaloids and Toxic Compound(s) in the Utilization of Tall Fescue by Ruminants

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Tall fescue (Festuca arundinacea Schreb) contains several alkaloids. Studies in our laboratory showed that perloline was a principal alkaloid in tall fescue during the summer, and that concentration peaked at a time when cattle grazing tall fescue pastures frequently have severely reduced performance (summer syndrome or summer fescue toxicosis). The objectives of the following studies were: (1) to determine the influence of perloline on in vitro fermentation and in vivo ruminant metabolism, and (2) to determine the effects of two tall fescue strains selected for perloline concentration on performance of growing cattle, lactating dairy cows and interrelationships with environmental temperature. In vitro fermentation studies showed a concentration-dependent inhibition of cellulose digestion, volatile fatty acid production and growth of ruminal cellulolytic bacteria by perloline. Isolated perloline fed to lambs resulted in decreased cellulose digestion and nitrogen retention, and increased body temperature. As a result of these studies, two strains of tall fescue were developed either high (G1-306) or low (G1-307) in perloline. A summer grazing study showed that gains of cattle on G1-307 were lower than those on Ky 31, Kenhy and G1-306. In a two-year study with lactating dairy cows fed Ky 31, G1-306 or G1-307 soilage, cows consuming G1-307 had the lowest intake and milk production, and highest respiration rate. These studies indicated that in the selection for low perloline, compound(s) more toxic and detrimental to animal performance were increased in G1-307. Further studies were conducted with dairy calves in environmental rooms to determine the influence of temperature and time of harvest of G1-307 on potential toxicity. Calves were fed July-cut G1-306 and G1-307 at 10-13, 21-23 and 34-35 C. Intake and weight change in calves decreased, while body temperature and respiration rate increased on G1-307 at 34-35 C resulting in temperature x forage interactions. In a subsequent trial in which soilage was fed in environmental rooms at 31-35 C from May, July and October harvests, gain and intake were decreased, and body temperature and respiration increased. Selection for low perloline in G1-307 resulted in concomitant increases in N-acetyl and N-formyl loline. Also, G1-307 N-acetyl and N-formyl loline concentrations were related to infestation with Epichloe typhina. Fields were established from seed of untreated and benomyl-treated G1-307 plants. Hay produced from benomyl-treated and untreated G1-307 had N-acetyl plus N-formyl loline concentrations of 115 and 875 ug/g and E. typhina infection estimates of 44 and 95%, respectively. Calves fed hay in 31-32 C rooms from benomyl-treated G1-307 had higher intakes and lower temperatures and respiration rates than those fed hay produced from untreated G1-307. These studies show that the toxic factor(s) in G1-307 are present from May through October, N-acetyl and N-formyl loline concentrations are related to E. typhina infestation, and toxic effects to the animal are potentiated by elevated environmental temperature.

Key words: tall fescue, ruminants, performance, alkaloids, perloline, N-acetyl and N-formyl loline, Epichloe typhina.

11-10-2 Beef Production from Tall Fescue Treated with Mefluidide, a Chemical Plant Growth Regulator

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Mefluidide treatment of Kentucky (Ky) 31 tall fescue (Festuca arundinacea Schreb.) in the spring will inhibit seed head formation, maintain the forage in an immature and vegetative state, and increase forage nitrogen (N) and soluble sugar (SS) content and in vivo nutrient utilization in the ovine. Productivity of animals grazing mefluidide treated tall fescue, however, has not been determined. The objective of this study was to evaluate agronomic characteristics of forage and productivity of yearling beef steers and heifers grazing mefluidide treated (T) and nontreated control (C) pastures of Ky 31 tall fescue.

Experimental pastures of Ky 31 fescue (four replications at location I and one replication at location II) were used to determine the effect of a spring application of 273.8 g mefluidide/ha on forage N, forage SS, and animal gain at 28-day intervals of two, 140-day grazing seasons.

Mefluidide treated forage had higher ($P<.05$) N content, compared with C, on day 56, 84, and 112 of the grazing season in both years. Forage SS content of T fescue was greater ($P<.05$) than C on day 28, 56, and 112 of the first year's grazing season and greater ($P<.05$) on day 28 in the second year. Animal gain from grazing T forage was increased 9.0, 22.0, 380.0, and 21.0% over C for 0 to 28, 28 to 56, 56 to 84, and 84 to 112-day periods, respectively. Combining gain data and analyses for forage treatment, year, location, and two- and three-way interactions produced a positive ($P<.01$) effect for mefluidide treatment.

Mefluidide treatment of Ky 31 tall fescue inhibited seed head formation, increased forage N and forage SS content, and produced a forage that is highly palatable and more efficiently utilized by grazing ruminants than nontreated forage. This resulted in a 27% increase in animal productivity per hectare.

Key words: tall fescue, beef productivity, Mefluidide, plant growth, regulator.

11-10-3 Effect of Nitrogen Fertilization of Kentucky-31 Tall Fescue (*Festuca arundinacea* Schreb.) on Brood Cow Health

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Studies were conducted to assess the long-term effects of nitrogen (N) fertilization of tall fescue on cow-calf performance and health problems including grass tetany, fat necrosis, gastro-intestinal parasitism and nitrate poisoning.

Kentucky-31 tall fescue pastures fertilized at three levels of N were grazed with Angus cows at 0.4 ha/cow on a year round basis. Fertilization levels included: high N (667 and 0 kg N/ha/yr from broiler litter in 1968-1974, and 1975-1977, respectively); moderate N (134 and 224 kg N/ha/yr from ammonium nitrate, NH_4NO_3, in 1969 and 1970-1977, respectively); low N (84 and 74 kg N/ha/yr from NH_4NO_3 in 1972 and 1973-1977, respectively). Within a year, cattle and pastures were managed similarly.

The overall mean available forage was 689, 1287 and 2167 kg/ha from 1973 to 1976 on the low, moderate and high N pastures, respectively. The percentage of tall fescue was 65.2, 73.6 and 82.2 for the respective pastures, with the bermudagrass and weeds component being higher on the low N tall fescue pasture. Mineral analyses of forage indicated a potential tetany hazard on all three pastures, yet from 1970 to 1977, 14, 9, and 0 cases of tetany occurred on the high, moderate and low N fertilized tall fescue, respectively.

Mean cow weights at each N fertilization level were different at 362, 410 and 443 for the low, moderate and high N tall fescue pastures, respectively. Respective actual weaning weights were 162, 182 and 188 kg. There was a tendency for lower (P=.11) conception rates (75%) on the moderate N pasture than on the low (90%) and high N (86%) pastures. Supplementing cows with Mg during the grass tetany season increased adjusted 205-day calf weights across all pasture treatments and increased conception rate in cows grazing the moderate N tall fescue pasture from 46 to 79 percent.

The incidence of fat necrosis increased as N fertilization level increased. The percentage of cows with palpable hard fat was 3.2, 9.8 and 53.7 for the low, moderate and high N tall fescue pastures, respectively.

Cows had significantly lower nematode egg counts than calves. Calves grazing the low, moderate and high N pastures had mean levels of 426, 261 and 137 eggs/g of feces, respectively.

At the stocking rate of .4 ha/cow, fertilization with 224 kg N/ha/year or greater enhanced grass tetany and fat necrosis problems. Nematode parasitism was associated with the quantity of forage available for consumption and consequently decreased as the level of N fertilization increased.

Key words: tall fescue, *Festuca arundinacea* Schreb., nitrogen fertilization, beef cow, reproduction, grass tetany, fat necrosis and parasitism.

11-10-4

Hydrocyanic Acid Potential in Stargrass (Cynodon spp.)

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The acreage of stargrass (*Cynodon nlemfuensis* var. *nlemfuensis*, *C. aethiopicus*, *C. dactylon* var *coursii*, *C. nlemfuensis* var. *robustus*) and bermudagrass (*C. dactylon* var. *aridus*) throughout the tropical and subtropical regions of the world has increased greatly. Reasons for their popularity include high yields, good quality, their competitiveness, and ability to produce during cool (15 to 20 C) temperatures. However, many of the *Cynodons* have a hydrocyanic acid potential (HCN-p) which may be toxic to livestock. The purpose of this study was to determine the HCN-p in fresh and hay samples of meristematic stem tips from nine *Cynodon* entries at different physiological stages of growth during the summer (19 to 33 C) and fall (11 to 32 C). Two selected entries ('Ona' and 'UF-5' stargrass) were also separated into meristematic stem tips, leaves and sheaths, and nodes and internodes at different stages of maturity to monitor HCN-p, dry matter (DM) and percentage of whole plant contributed by plant components. Correlations were determined between HCN-p concentration and total solar radiation All plant entries were staged at 7.5 cm and received 280-25-93 kg/ha of nitrogen (N), phosphorus (P), and potassium (K) one week prior to commencement of the summer and fall studies. The HCN-p was measured by an alkaline picrate colorimetric procedure.

Significant differences in HCN-p concentration in meristematic stem tips were obtained among the nine *Cynodon* entries over a 2-year period. The HCN-p concentration basically followed either high or low levels. High level HCN-p grasses averaged 407 and 529 ppm on a fresh weight (FW) basis during the summer and fall period, respectively. Low HCN-p grasses averaged 121 and 131 ppm FW, during summer and fall, respectively. Average HCN-p concentrations were lowest for 'Callie' bermudagrass (75 ppm) and highest for 'Puerto Rico' stargrass (506 ppm). All entries decreased with maturity during the hot, wet summer. However, during the cool, dry fall, HCN-p tended to remain high until temperatures fell below freezing. After a freeze HCN-p decreased 92% to 43 ppm and 78% to 25 ppm in high and low level grasses, respectively. Meristematic tips dried to 85% DM decreased in HCN-p by 88 and 78% for high and low level grasses, when compared with fresh samples. Significant correlations ($r=0.56^*$) were found between HCN-p and total solar radiation 1 day before and an average of 7 days prior to HCN-p analysis. Dividing two grass species into plant parts for DM and HCN-p determination revealed similar DM levels in Ona and UF-5. However, HCN-p of whole UF-5, plants tips, leaves and sheaths was consistently lower ($P<0.05$) than Ona stargrass. The meristematic tips generally contained the highest ($P<0.05$) HCN-p regardless of species. These data indicated differences ($P<0.05$) in HCN-p concentrations between stargrass and bermudagrass (*Cynodon* spp.) entries. The results provide HCN-p levels in *Cynodon* spp., which can be beneficial when managing tropical grasses.

Key words: hydrocyanic acid potential (HCN-p), stargrass, *Cynodons*, tropical grasses.

11-10-5 Review of Mechanisms of Toxicity of 3-Nitropropanoic Acid in Nonruminant Animals

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Crownvetch (Coronilla varia L.) currently has limited use in the U.S. as a forage crop for ruminant animals. Even though crownvetch forage can contain high amounts of nutrients, intake by ruminants may be reduced. Toxicity problems upon feeding crownvetch to nonruminants have been traced to 3-nitropropanoic acid (NPA), which occurs esterified to glucose in the plant. Understanding mechanisms of toxicity in nonruminants will be helpful in avoiding livestock losses and in treating poisoned animals.

Symptoms of NPA toxicity are similar in rats, mice, meadow voles, chickens, and rabbits, and probably reflect central nervous system disorders and oxygen deprivation. The other major symptom of NPA poisoning in animals is elevated serum levels of methemoglobin, a nonfunctioning form of hemoglobin. Methemoglobinemia indicates severely depressed respiration, but this condition by itself does not cause death. NPA metabolism in nonruminants evidently produces nitrite ions, which combine with hemoglobin to form methemoglobin, since sodium nitrite mimics NPA in this respect. Some additional mechanism is needed to explain NPA toxicity.

Investigators have found that approximately 1% of NPA in the circulation of intoxicated animals is converted to a dianionic carbanion and that the NPA carbanion concentration is sufficiently high to irreversibly inhibit succinate dehydrogenase. Under these conditions, NPA carbanion also competitively inhibits fumarase. These two mitochondrial enzymes catalyze sequential steps in the Krebs cycle, both essential to normal respiration. Two mechanisms for inhibition of succinate dehydrogenase by NPA carbanion have been proposed; the mechanism least acceptable on chemical grounds accounts for nitrite appearance in animals (as methemoglobin) but the second, for which the chemical evidence is most convincing, does not account for nitrite release from NPA. Recent data indicate that NPA might be oxidized by a liver microsomal monooxygenase, thus producing nitrite.

NPA apparently acts in two ways in exerting its toxic effects: 1) Inhibition of two mitochondrial enzymes essential to respiration, succinate dehydrogenase (irreversibly) and fumarase (competitively), and 2) methemoglobin formation as a result of metabolic breakdown of NPA to nitrite ion.

Key words: crownvetch, Coronilla varia, Astragalus spp., 3-Nitropropanoic acid, NPA, toxicity, Methemoglobinemia, succinate dehydrogenase, fumarase.

11-11-1 Relation of Animal Production to Stocking Rate on Cultivated Pastures in Cerrado Areas of Brazil

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The relationships among stocking rate, gain per animal and gain per hectare were compared on seven grazed pastures. The experiment was established on an oxisol acrustox, in Brazil. The pastures consisted of 1) jaragua grass; 2) jaragua grass plus legumes; 3) molasses grass; 4) molasses grass plus legumes; 5) pangola grass; 6) pangola grass plus legumes; 7) mixture of grasses (jaragua, molasses and pangola) plus legumes. Pasture 5 was discarded because of poor establishment. Four stocking rates were applied on each pasture from 1.0 to 3.4 animals/ha.

For all pastures, gains per animal decreased linearly ($P<0.05$) with increasing stocking rate. No significance was found among the slopes of all the six linear regressions for each pasture, nor among years. On the other hand, the adjusted means of the pastures 1, 2, 6, and 7 were significantly higher than those of pastures 3 and 4. Liveweight gains were significantly related to pasture availability during the wet period of 1975-76 and 1976-77 and during the dry period of 1976-77. The highest stocking rates at which pastures 1, 2, 6, and 7 persisted for more than five years were 2.0, 1.4, 2.0, and 2.0 animals/ha respectively. The experiment showed that some cultivated pastures grazed continuously and stocked at no more than 2.0 animals/hectare had a production five times higher than those of the region in general.

Key words: grazing, stocking rate, hyparrhenia, melinis, digitaria, tropical legumes.

11-11-2 Effect of Stocking Rate on Milk Production of Cows Grazing Bermuda Grass (*Cynodon dactylon* cv Coast Cross No. 1), Improved Star Grass (*Cynodon nlenfuensis*) and Pangola Grass (*Digitaria decumbens*, Stent)

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Seventy-two Holstein heifers were used during two first lactation periods to study the effects of stocking rate (3, 4, and 5 cows/ha) and pasture species (bermuda grass, star grass and pangola grass) in a 3 x 3 factorial arrangement on milk production, other grass measurements and animal performance. Pastures were fertilized at a rate of 400 kg N/ha/year and 50 mm of water every two weeks in the dry season (November-April). Concentrates were offered up to the tenth lactation week at a rate of 0.5 kg/liter after the fifth lactation week. Afterwards, pasture and ad libitum mineral salts were supplied as the sole feed. The animals were rotated every 21 days and were kept in the paddock for 7 days in the first lactation and 21 and 4 days in the second lactation. A multiplicative model was used for the analysis of the results to control some effects such as the lactation curve. Pasture x stocking rate interaction was not significant and milk production did not differ between pasture species but did between stocking rates ($P<0.05$). There was a stocking rate x pasture interaction ($P<0.001$) in the second lactation. Milk production (305 days) was 3844, 3224 and 2890 liters for 3, 4 and 5 cows/ha in bermuda grass; 3116, 3267 and 3627 for star grass and 3896, 3224 and 2621 in pangola grass. The results showed a higher star grass production/ha with the highest stocking rate (18.133 liters) and suggested that the stocking rate on star grass could be increased while on bermuda and pangola grasses, individual production decreased as stocking rate increased.

Key words: *Cynodon dactylon*, *Cynodon nlenfuensis*, *Digitaria decumbens*, stocking rate, milk production.

11-11-3 Effect of Grazing Pressure on Daily Live Weight Gain in Calves Grazing Bermuda Grass (*Cynodon dactylon* cross No. 1)

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The objective of this work was to assess the effect of grazing pressure on live weight gain in calves grazing cross bermuda grass No. 1. The following indicators, individual live weight (LW) daily gain (y), LW/ha (y_2) and LW/100 kg live weight (y_3), obtained in various experiments were related by means of multiple regression equations to LW/ha, DM pasture availability/ha, LW/availability relationships, availability/LW, LW of calves, supplementation in g/kg LW and fiber/nitrogen of grass offered in these trials. Individual gain was related according to the following equation; $y_1 = 0.0122 - 0.0028\ x_1 + 0.00031\ x_2 + 0.32\ x_3 - 0.00000012\ x_2^2 - 0.049\ x_3^2$ with $r^2 = 0.41$ ($P<0.001$). Gain/ha was adjusted to $P<0.01$ according to $y_2 = 5.669 - 0.128\ x_1 + 5.995\ x_3 - 0.00000046\ x_2^2 - 0.0942\ x_3^2$ equation with $r = 0.37$ and gain as LW% was adjusted to $P<0.001$ according to $y_3 = 0.540 - 0.0075\ x_1 + 0.00019\ x_2 - 0.37\ x_3 - 0.000000096\ x_2^2 - 0.059\ x_3^2$ with $r^2 = 0.55$. On including supplementation and CF/N rates correlation values improved.

It is concluded that grazing pressure is much more effective than the number of animals/ha in predicting grazing capacity and that this is dependent on the LW of calves and availability and quality of grass offered.

Key Words: *Cynodon dactylon*, grazing pressure, calves, live weight, gain.

11-11-4

Relationships Among Stocking Rate, Pasture Availability, and Weight Gain on Coastcross II Bermudagrass Pastures

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Coastcross II Bermudagrass is a relatively new introduction to South Africa and little is known about its management requirements. Continuous grazing, as opposed to rotational grazing, is considered to be almost a malpractice in South Africa. This has developed from the necessity of applying rotational grazing to the natural range, in which severe selection and subsequent deterioration occurs under continuous grazing, mainly due to the large differences in acceptability among the range species. In cultivated pastures, however, this problem does not exist, yet there are still few stockmen who graze their artificial pastures continuously. While some may use rotational grazing for other reasons, there are those who believe that it results in higher production per hectare than continuous grazing, and that it is less damaging to the pasture. The objective of the research reported in this paper was to evaluate Coastcross II Bermudagrass under continuous and rotational grazing by examining relationships among stocking rate, pasture availability, amd weight gains.

Coastcross pastures were grazed by young beef animals for four summer growing periods starting in 1976. Under continuous grazing a number of different levels of pasture availability were established and maintained throughout the experimental period by applying variable stocking. Rotational grazing involved rotating animals through six subdivisions. In some rotations animals were forced to graze subdivisions severely before they were moved, while in others a more lenient utilization was allowed. Pasture availability was monitored at weekly intervals on all paddocks with the pasture disk meter. Regression analysis was used to interpret results.

Relationships between pasture availability and weight gain were consistently linear within and between seasons. However, regression coefficients differed within and between seasons and between continuously grazed and rotationally grazed treatments. On the other hand, relationships between stocking rate and weight gain were not always linear. They also changed within and between seasons and depended on whether the pasture was grazed rotationally or continuously.

Results demonstrated that pasture availability is a crucial factor through which stocking rate affects weight gain, and that there is no sound biological reason for applying rotational grazing in preference to continuous grazing on Coastcross II Bermudagrass, provided a moderate level of pasture availability is maintained.

Key words: Coastcross II Bermudagrass, continuous grazing, rotational, stocking rate, availability.

12-1-1 Beef Production from Tropical Grass-Legume Pastures in the "Cerrados" of Brazil

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A grazing trial was conducted in Central Brazil to measure the effects of levels of maintenance fertilization on a grass-legume association in terms of forage production, botanical composition, liveweight gain/animal, animals/hectare and liveweight gain/hectare. Replicated pastures were planted with a local cultivar of Panicum maximum in mixture with Stylosanthes guianensis cv Endeavour and Macroptilium atropurpureum cv Siratro. Zebu steers were used at approximately the same grazing pressure.

After clearing the "Cerrado" dolomitic lime was applied (2t/ha). Corrective fertilization was made with thermophosphate (100 kg P_2O5/ha), potassium sulfate (70 kg K_2O/ha) and FTE-Br-10 (25 kg/ha). In subsequent years after pasture establishment, applications of single super phosphate (20 and 40 kg P_2O_5/ha) and potassium chloride (20 and 40 kg K_2O/ha) were made each February. The pasture that received no maintenance fertilization (zero level) showed lower percentages of P. maximum and legumes and more weeds, compared to those that received fertilization. The fertilization levels used modified the chemical composition of the forage. All the forages, except in the 0 level treatment, met the P and K requirements of grazing cattle for production.

Animal liveweight gains during the first year were 229, 339 and 376 kg/ha for the 0,20 and 40 kg/ha levels of fertilization, respectively ($P < 0,05$-1975/1976). During the second year, the liveweight gains were 170, 340 and 449 kg/ha ($P < 0,05$-1976/1977) respectively for the three levels considered. For the third year, the liveweight gains were 150, 355 and 476 kg/ha (P 0,05-1978/1979) respectively.

Comparing the results of the three years, it can be seen that the 20 kg/ha level tends to maintain production. The 40 kg/ha level tends to increase production, while the 0 level tends to decrease it.

The level of animal production which can be attained in grass-legume systems in the Brazilian Cerrados is dependent upon the level of available nutrients, legume content of the pastures and grazing management.

Key words: Panicum maximum, Stylosanthes guianensis, Macroptilium atropurpureum, maintenance fertilization, beef production.

12-1-2 Milk Production and Live Weight Gains in Cows and Holstein Steers Receiving Elephantgrass Green Fodder

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Our objectives were: to estimate the potential of elephantgrass green fodder for milk production and live weight gains in Holstein cows and steers, to evaluate the effect of the concentrate supplementation on herbage intake and milk production and to obtain a preliminary information of green fodder intake in steers and lactating cows.

Two trials were carried out simultaneously. In one trial the experimental design was a Latin square 3 x 3 with six weeks periods. Six Holstein cows in mid lactation were used, the treatments were three levels of supplementation (0.3 and 6 kg/day ad libitum). In the other trial nine Holstein steers, in a continuous design, received the same basal diet ad libitum only. Twelve Colombian Red sheep were used to determine forage DMD but no older than 64 days. The periods I - II were at the end of the dry season; the period III was at the rainy season.

The concentrate had a small effect on forage intake and there was a slight response of milk yield to concentrate supplementation (0.33 kg milk/kg concentrate). The latter effect was probably caused partially by the advance of the lactation curve and the low milk yield levels of the cows used. The cows on the basal diet had specially low intakes and a relatively high milk production (6.7 kg/day) but an appreciable loss of weight. The remarkable intake differences between steers and cows (2.240 vs 0.827 kg DM 100 kg lw^{-1}, respectively) receiving the basal diet only are not explainable in the terms of the experiment. Probably there was a residual effect of the concentrate supplementation on the utilization of the forage in lactating cows. The lower values of intake in the period II in steers and sheep (272, 205, 193 (steers) and 293, 2.51, 3.57 kg DM 100 kg lw^{-1} (sheep) in the periods I, II & III, respectively) reflects a season effect on the herbage quality not related to plant morphological changes.

The intake difference between steers and sheep in the period III was probably occasioned by a direct depressive influence of the rainy season on intake by steers.

Key words: milk production, live weight gains, herbage intake, elephantgrass, cows, steers, supplementation.

12-1-3 Productivity of Sheep Grazing *Brachiaria ruziziensis* Mixed with Legumes in a Wet Environment

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A grazing experiment was conducted in Bogor, Indonesia, in 1976-1978 to measure the effect of pasture improvement on weight gain by sheep. The location of the experiment was 900 m above sea level on a latosolic soil with medium fertility and 4507 mm average annual rainfall. The yearly temperature is 25°C. Three different pastures were used: natural, *Brachiaria ruziziensis*, and a mixed pasture of *B. ruziziensis* and the legumes *Centrosema pubescens*, *Desmodium uncinatum*, *Macroptilium atropurpureum*, *Pueraria phaseoloides* and *Stylosanthes guianensis*. No fertilizer was applied except for the mixed pasture, to which 150 kg triple superphosphate was applied to stimulate growth of the legumes. Three different stocking rates were exercised on each pasture: low, medium and high. For the natural pasture these were equivalent to 32, 41 and 53 sheep per ha; for the *Brachiaria* pasture 53, 67 and 89 sheep per ha, and for the mixed pasture 53, 70 and 84 sheep per ha. The sheep used were local male sheep approximately 8 months old. The grazing pattern was a permanent 24 hours grazing for a 5-month grazing period. The 3 x 3 factorial experiment was replicated four times.

Data from the second year showed that the *Brachiaria*/legumes pasture resulted in highest liveweight gains for the average stocking rate, 8.52 kg, while the *Brachiaria* and natural pasture produced 3.79 kg and 1.21 kg, respectively. The data also showed that, on all pastures, the higher the stocking rate the lower the liveweight gain: 6.54, 5.35, and 2.6 kg for the respective low, medium and high stocking rate.

The optimum stocking rates for the natural, the *Brachiaria* and the *Brachiaria*/legumes pasture were 28, 51 and 60 sheep/ha/5 months and expected total liveweight gains were as high as 35, 158 and 306 kg respectively. Improvement of natural pasture with *B. ruziziensis* alone did not equal the mixture of *B. ruziziensis* and legumes.

The legumes that showed the best compatability with *B. ruziziensis* were *Stylosanthes guianensis* and *Desmodium uncinatum*.

Key words: amino acid, stocking rate, natural pasture, *Brachiaria ruziziensis*, *Stylosanthes guianensis*, *Desmodium uncinatum*.

12-1-4 Hog Feeding with Napier Grass in Taiwan

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Napier grass, Pennisetum purpureum Schu. is a bunch type tropical grass. It responds well to fertilizing and recovers quickly after cutting. It is the leading soilage species cultivated in Taiwan for cattle feeding.

It has been tried as a feed for hogs by the first author since 1960. At first the grass was chopped before feeding to hogs, which face the problem of excessive fiber intake. Therefore, this succulent grass was fed to hogs unchopped; hogs chew this grass for its juice without swallowing the pulp. Farmers consider it a good idea to supplement some minerals and vitamins by giving a small amount of napier grass to the swine.

After the energy and grain crises in 1973, more serious consideration was given to the use of napier grass to replace part of the concentrates for swine feeding. Several feeding trials were conducted after 1974. Two of them are presented here. One experiment was to feed napier grass cut at 1 m stage and at 2 m stage, and a check treatment without feeding napier, 9 pigs in each treatment, from 20 kg live weight to 90 kg finished. Feed composition of the napier grass was determined. Concentrates fed were adjusted in amount according to the quality of the napier grass. Napier soilage consumption averaged 1.4 kg daily per pig. Feed conversion rate was 3.88 for the check, 3.54 for the younger napier and 3.65 for the more matured napier treatment.

The other feeding trial used expressed juice of napier grass. The 3 treatments were the check, and pigs fed with 1 kg juice and with 2 kg juice daily per pig. The concentrates were deducted 0.12 kg for every 1 kg juice fed. Composition of the expressed juice was determined. The feed conversion for the check was 3.69, for the 1 kg juice treatment 3.58, and 3.21 for the pigs fed with 2 kg juice daily. There were 20 pigs in 5 pens assigned to each treatment, starting from 16 kg live weight to 90 kg live weight.

Since all the feeding trials on swine fed with napier grass showed beneficial effect, its application for tropical regions where concentrates may be expensive and not fully available, has economic importance.

Key words: napier grass, Pennisetum purpureum Schu., soilage, swine, tropical, Taiwan.

12-1-5

Mass Gains of Beef Cattle on Grasslands in South Africa

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This paper summarises the results of a number of grazing trials with beef cattle on various grasslands in the frosty, high rainfall (750-1 000 mm) areas of Natal, South Africa. These areas represent some 2.3 million ha or 47% of the province.

Beef type yearling steers or cows with calves at foot were grazed in rotational grazing systems using a range of stocking rates. Animal mass gains were determined regularly over the spring to autumn grazing period (c 180 days). The duration of the trials varied from 2 to 13 years and from 12 to 77 sets of data are available for each pasture type with each of the two classes of animal. Results are presented for natural grassland, reinforced grassland (fertilized and oversown or sod-seeded) and planted pasture. All results are from dryland conditions and were processed with the aid of the stocking rate animal performance model of Jones & Sandland (1974).

The maximum gain/ha for steers is estimated to be 120 kg with an ADG (average daily gain/animal) of 0,35 kg at a stocking rate of 2.0 animals/ha on natural grassland; 350 kg with an ADG of 0.40 kg at 4.6 animals/ha on reinforced grassland and 840 kg with an ADG of 0.40 kg at 11.1 animals/ha on planted pasture. Degraded veld produced only 60 kg gain/ha with an ADG of 0.35 kg at 0.9 animals/ha.

The maximum gain/ha for calves is estimated to be 170 kg with an ADG of 0.45 kg at a stocking rate of 2.2 cows and calves/ha on veld; 240 kg with an ADG of 0.60 kg at 2.2 cows and calves/ha on reinforced grassland and 840 kg with an ADG of 0.55 kg at 8.5 cows and calves/ha on planted pasture.

Some 3 million ha of natural grassland can be improved in the high rainfall, frosty areas of Natal. Such improvement could lead to a three-fold increase in beef production on 60% of the area and a six-fold increase on a further 30% of the area.

The economics of improving grassland for beef production are dependant on the cost: beef price ratio. At present in the areas under discussion this ratio for growing out steers is 1:1,8 on veld and 1:1,6-1,7 on improved grassland. Thus at present the profitability of the three systems is evenly balanced with a slight advantage for veld.

Key words: types of grassland, livemass production, beef cattle.

12-2-2 Pasture Research Project in the Brazilian Amazon

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The common procedure for pasture establishment in the Brazilian Amazon has been the cutting down of forest and burning of the felled vegetation, followed by aerial seeding of guinea grass (Panicum maximum L.). Under normal management practices, animal production has dropped significantly as the pastures deteriorated and were invaded by weeds. The dearth of knowledge available in terms of climate, soil and plant species, for the manner in which pastures were planted, managed and stocked, allied to a complete absence of fertilizing, led to overgrazing and complete degradation of the pastures. The objective of the study was to identify soil problems, adapted forage species, pasture management practices and ways of regenerating the pastures. Two representative regions were selected: Northeast Mato Grosso and Paragominas-State of Para, where the largest of the cattle projects are concentrated. The procedure was to install introduction garden plots with over 100 forage species, followed by fertilizer a . lime experiments with the most promising species. At the same tim plot studies were conducted to determine the principal nutrient problems. Under field conditions, experiments were installed with the best species, fertilized adequately and their performance was evaluated. Specific experiments aimed at the recuperation of pastures through fertilization, use of herbicides and other agricultural practices. The duration of the investigation was 5 years. Results: identification of the nutrient phosphorus as the limiting factor in the development and normal persistence of guinea grass; positive results with low levels of phosphorus (50-75 kg/ha) alone or together with limestone, for the recuperation of severely deteriorated guinea grass infested with weeds; efficiency in the use of 2-4-D in the recuperation of weed-infested pastures. Selection of approximately 17 of the most promising forage species adaptable for use in the Amazon. Conclusions: necessity of phosphorus to maintain the initial production capacity of guinea grass as well as its persistence; utilization of phosphorus together with dolomitic lime recommended for the renovation of guinea grass pastures; practicality of using herbicides to recuperate weed infested pastures. Approximat ly 17 new vegetative species were identified as adaptable, opening new forage alternatives. Significance: considering 2.5 million hectares of existing pastures for beef cattle production and without knowledge of how to maintain or recuperate, the results obtained were the first in the Brazilian Amazon.

Key words: Amazon pasture, forage, tropical soils, guinea grass, Panicum maximum L.

12-2-1 Intensive Beef Production in the Humid Tropics: An Evaluation of Technical and Economic Feasibility

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Some parts of the humid tropics show great potential for intensive livestock production from forages. However, in many cases, economic analyses have not been performed.

In this study technical and economic feasibility of three strategies for developing intensive pasture for beef production are evaluated. These strategies are fast development (no capital limitations) using commercial nitrogen (N), slow development using commercial N, and slow development using legumes as a N source.

The strategies are based on experimental data and experience from the Orinoco Delta, Venezuela. Pastures of Pangola (Digitaria decumbens) and Swazi (D. swazilandensis) were rotationally grazed with unselected Criollo/Zebu cattle. Liveweight gains of 550 g/head/day and 1000 kg/ha/year were obtained.

Using 1974 prices and a 30 year period, net annual cash flow (NACF), debt payback period (DPP), net present value (NPV), and annual profit after the debt is paid are used to evaluate economic feasibility. Sensitivity analyses are performed varying interest and discount rates, investment and operating costs and livestock receipts.

Under the fast pasture development with no capital constraints alternative, NPV is highest and DPP is shortest. With slow pasture development using commercial N, NPV is negative and DPP is longest. NPV is positive with slow pasture development using legumes. NACF budgets indicate that receipts are greater than expenses earliest but accumulated debt greatest, with fast pasture development. All three strategies result in extremely profitable farms once the developmental process is completed and the accumulated debt is paid. The farm in which legumes are substituted for commercial N is most profitable.

Development of intensive beef production in the Orinoco Delta is technically feasible. Most economic criteria used indicate that a developmental strategy with fast pasture development is most desirable. Slow pasture development using commercial N is least desirable and may not be economically feasible. The economic feasibility of all three strategies is very sensitive to changes in interest rate, discount rate, operating costs or livestock receipts. Development of intensive beef production could be encouraged by government subsidization of capital or by government policies which result in favorable levels of operating costs or livestock receipts.

Key words: beef, humid tropics, economic evaluation, pasture, legumes, investment.

12-2-3 Pasture Research Results in the Brazilian Amazon

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Until the late 60's, cattle raising in the Amazon Region was based almost exclusively on extensive exploitation of natural grasslands In the last 20 years, an aggressive cattle raising development has taken place, based primarily on improved pastures in forest areas.

Natural upland savanna grasslands are represented mainly by well-drained savannas where the cerrado-type savanna is the predominant ecosystem, and by poorly-drained savannas, where the campo alto-type is the most common ecosystem. Their main limitations are low forage production potential and, especially, low forage quality.

About 3 million ha of rain forest have been replaced by improved pastures of Guinea grass (Panicum maximum - 80 %), Jaragua grass (Hyparrhenia rufa - 10 %), and Brachiaria spp and other grasses (10 %). During the first few years after establishment, pastures are rather productive. However, with time, a gradual decline of productivity occurs, especially in P. maximum pastures. About 0.5 million ha are already in advanced stages of degradation. Limiting factors include climate, plant and soil factors, besides man's influence.

Research was conducted on 14 private ranches representing the most important improved and native pasture ecosystems of the Amazon Region with the objective of developing technology for a) reclaiming sown pastures at varying degrees of degradation, b) increasing the longevity of still-productive sown pastures in forest areas, and c) increasing productivity of low-producing native pasture ecosystems. Similar trials are being conducted at all sites along the following research lines: 1) introduction and evaluation of commercial forage species; 2) evaluation of grass-legume mixtures; 3) forage fertilization; 4) pasture reclamation, improvement and management (grazing trials); and 5) adaptation of new forage germplasms.

In forest areas, results indicate that: a) maintenance of pasture productivity requires careful management of the soil-animal-plant system; b) even though Guinea grass has been planted on 2.5 million ha, other grasses can be more successful; c) longevity of still-productive Guinea grass pastures can be considerably increased by using appropriate grazing management systems in combination with strategic use of phosphorus fertilization and legume introduction; d) reclamation of Guinea grass pastures in advanced stages of degradation can be successfully achieved with low-demand grasses such as Brachiaria humidicola in combination with legumes, such as Pueraria phaseoloides, and phosphorus fertilization.

Results indicate that native upland grassland ecosystems can have their productivity considerably increased with appropriate management, phosphorus fertilization, and forage grasses and legumes suitable for their acid and infertile soils.

Key words: Amazon Region, tropical savanna, tropical forest, guinea grass, Quicuio-da-Amazonia grass, Brachiaria humidicola, Pueraria phaseoloides, oxisols, ultisols.

12-2-4 Advances in Pasture Research and Development in Santa Cruz, Bolivia

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Cattle production is important in Santa Cruz, but productivity is low due in part to low grazing-value of natural pastures particularly in the dry season. Other constraints to cattle production include low land values, poor management, high cost of in-puts and relatively low product prices. This programme aimed at providing higher quality, low-cost pastures for complementary use within traditional grazing systems.

Improved introduced species were identified for five agro-ecological zones and commercial seed production of the following was encouraged - Petrie guinea (Panicum maximum), Brachiaria decumbens, buffel (Cenchrus ciliaris), glycine (G. wightii), Archer (Macrotyloma axillare), lab-lab (L. purpureus) and stylo (Stylosanthes guianensis).

The value of legume-based pastures was measured and demonstrated in grazing trials, where dry-season access to legumes as mixed swards or as a protein reserve significantly improved animal production. Cattle were raised to 400 kg liveweight in 30 months without supplementary feeding.

These results have been used in model projections to view pasture and animal production in the whole-farm context and to illustrate the economic feasibility of pasture improvement.

Training and extension activities were undertaken.

Key words: legumes, grasses, cattle, dry-season, ranch production, seed production.

12-2-5 Development of a Pasture Research Program for the Tropical Savanna Region of Brazil

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The tropical savannas (Cerrados) of the center-west region of Brazil contain almost 40 percent of the nation's cattle population. However, the low productivity and nutritive value of the native pastures is a serious limitation to cattle production. To improve the nutrition of the grazing animal a research program has been developed with emphasis on the integrated use of cultivated pastures. The program aims (i) to select species adapted to the Cerrados (ii) to determine their nutrient requirements and (iii) to develop methods of establishment and utilization. The program is being conducted at the Cerrados Agricultural Research Center (CPAC) at latitude 15°S. Rainfall is 1578 mm per annum distributed in a 5 to 6 month wet season from October to March.

A systematic 3-stage pasture evaluation scheme has been implemented. In stage I there are 680 legume and 126 grass accessions under test on the two major soils of the region. The principal genera are Stylosanthes Sw., Panicum L., Andropogon L., Brachiaria Griseb. and Melinis Beauv. Observations are made on phenology, productivity, nutritive value, seed production, animal acceptability, tolerance to pests and diseases. Promising accessions pass to stage II where simple grass-legume mixtures are evaluated in small, individually-grazed plots for compatibility, persistence and productivity. Currently, 19 accessions are included in stage II. In stage III grazing trials are conducted where year-round animal performance is monitored on the most promising mixtures at three set-stocking rates.

Soil fertility and plant nutrition studies are being undertaken in two stages. First, exploratory greenhouse experiments are set up with treatments arranged factorially to identify the most important soil nutrient deficiencies. Second, field experiments are designed to verify the greenhouse studies and to determine the amount and kind of fertilizers required for pasture establishment and maintenance.

A comprehensive program has been initiated to develop methods of pasture establishment. These include investigation of conventional planting techniques, undersowing of arable crops, legume introduction into native and degraded cultivated pastures by oversowing and sod-seeding.

In the Cerrados 95 percent of beef producers are involved in cow-calf operations. Therefore, pasture utilization studies are designed to investigate the strategic use of new cultivated pastures for improving reproductive performance of cows, reducing age at first calving of heifers and for rearing early-weaned calves.

Preliminary observations are presented for the various studies in progress.

Key words: savannas, Cerrados, Brazil, pastures, evaluation, fertility, establishment, utilization.

12-3-1 Diet Quality Considerations in the Design and Management of Pastures in the Seasonally Dry Tropics of Australia

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Much of Australian tropical pasture research in the last 20 years has been aimed at filling the 'protein gap' of the dry season with a well adapted legume. Several such legumes are now available, but their contribution to an improved nutritional regime has been variable. This paper puts forward generalizations as to the contribution to cattle nutrition of pasture components and attempts to apply this information in devising regional strategies for pasture design and management.

The contribution of a forage component is a function of (a) its nutritive value and (b) its relative acceptability. Three components emerge as both highly nutritious and acceptable, i.e., young green grass, mature green legume, and legume litter (mainly leaf and seed).

Young grass dominates the diet from first storms until late in the rainy season. Drastic reduction in grass quality corresponds with peak yields of mature green legume, and diet composition changes correspondingly. Green legume remains the major diet component until soil water depletion triggers senescence and leaf shed.

During the dry feed period, legume litter is capable of supporting liveweight gain unless rainfall causes spoilage. Sufficient rain to promote substantial grass growth can also have a net benefit. The most deleterious situation is one of small falls, sufficient to cause spoilage, but insufficient to support growth. Dry season rainfall in the beef producing regions of tropical Australia is highly variable both geographically and temporally. Figures are presented which show (a) the variation in the risk of rainfall damage to dry legume and (b) the probability of green grass availability. These provide a basis for design of pastures and management for various regions. Strategies for two contrasting environments are discussed.

Although the goal of a well adapted, high yielding pasture legume for the semi-arid tropics has been achieved, there remains a major task in optimizing utilization of such a plant in production systems over a wide range of environments.

Key words: tropical pastures, pasture legumes, Stylosanthes, beef cattle, diet selection, agro-climatology.

12-3-2 Development of Legume-Based Pastures for Beef Production in Dry Tropical Areas of Northern Australia

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A program designed to select pasture legume species suitable for use in the 500-1500 mm annual rainfall zone of northern Australia is described. Extensive beef cattle grazing is the major form of land use in the region but animal productivity from native pastures is low due to the low herbage quality of the native grasses for most of the year. The program aimed to improve the herbage quality by introducing suitable legumes.

Despite a number of shortcomings, the annual legume Townsville stylo (Stylosanthes humilis) possessed the potential to increase animal production, so a detailed study was made of other members of the genus to determine if any contained useful pasture plants. The program, which involved spaced plant studies and small-scale cutting trials at a number of sites, identified a number of persistent, high yielding accessions.

Animal production studies have been made with some of these accessions at a number of sites. The introduction of a legume into native pasture generally results in an increase in carrying capacity although production per head may not increase unless superphosphate is applied. The Stylosanthes accessions can produce moderate to high yields without superphosphate and only small applications of superphosphate may be necessary to give large increases in animal production. The major contributions of the legumes are to prolong the period of liveweight gain and to reduce or eliminate dry season weight losses.

This program has led to the release of cultivars in three species - S. hamata, S. scabra and S. guianensis and has shown that productive legume stands can be grown in dry tropical areas receiving more than 600 mm of rain per annum. This substantially increases the area where legume-based pasture improvement can be applied in northern Australia. Productive stands have also been grown in other countries and offer the potential for increased animal production in those areas.

Key words: legume evaluation, Stylosanthes species, animal production.

12-3-3

Growing Beef Cattle on Native Pasture Oversown with the Legume Fine-stem Stylo in Sub-Tropical Australia

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Fine-stem stylo (FSS), Stylosanthes guianensis var. intermedia, is a perennial legume suitable for sowing into native Heteropogon contortus pastures on well-drained soils in south eastern Queensland. A grazing system is described that aims to maintain a productive FSS pasture and grow steers to 480 kg liveweight at 27 months of age. This requires gains of 300 kg steer^{-1} in 20 months after weaning. Results from a short-term field study of the system were analysed for long-term repeatability using a simple model that predicted animal production from stocking rate and weather records.

The system was studied near Gayndah, Queensland, on 11.3 ha of FSS/H. contortus pasture invaded by Rhynchelytrum repens. Each June after weaning, 7 steers (5/8 Hereford, 3/8 Sahiwal) commenced a 20 month grazing cycle. Thus two animal classes grazed together from June to January. From February to May, after the older animals were slaughtered, the stocking rate was halved to allow FSS to grow before winter. The mean annual stocking rate was 1.0 steers ha^{-1}.

Since 1976 three grazing cycles have been completed with total liveweight changes of 276, 326 and 315 kg steer^{-1}, to give carcasses suited to local trade. FSS contributed 10% of pasture yield, but weeds progressively increased.

The animal production model predicted liveweight change (LWC) in winter, spring + summer, and autumn from pasture growth index per head, the mean growth index (GIX) for a season divided by stocking rate (SR). GIX was the product of separate indices (range 0 to 1) for temperature, solar radiation, and soil water supply. The regressions predicting LWC from GIX/SR were derived from results of the field study and two published studies; they accounted for 85 to 89% of variation in LWC.

Complete weather records (1958 - 1980) were processed to estimate GIX from seasonal rainfall and GIX in the previous season. This enabled LWC to be simulated from monthly rainfall from 1970 to 1980. Three mean annual stocking rates (0.74, 1.0, 1.3 steers ha^{-1}) were considered over 109 grazing cycles. Frequency distributions of total liveweight gain showed that SR affected repeatability.

The model estimated long-term repeatability from a restricted data base but ignored possible influences of extreme feed shortages and changes in soil fertility and botanical composition on LWC. It supported the field study by indicating a reduction in SR would improve repeatability of production and reduce weeds; provided information that would otherwise have to come from a long-term grazing trial; suggested pasture stability in drought should be studied; and indicated the grazing system is suitable for commercial application.

Key words: fine-stem stylo, Stylosanthes guianensis, beef cattle, native pasture, simulation, growth index.

12-3-4 The Value of Lucerne As a Grazing Supplement for Sheep Grazing Natural Pastures in a Semiarid Area of Australia

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In the central areas of New South Wales, Australia, the natural pastures are dominated by annual species which grow during the cooler months producing good quality grazing which is particularly abundant during spring. However, these species mature rapidly in late spring and provide poor quality summer grazing. The four year study reported was designed to examine the value of sown lucerne equivalent to one-third of the total area as a supplement to be grazed mainly during late spring and summer.

The availability of lucerne for spring grazing by ewes and lambs was only of benefit in one year when maturing grass seeds were abundant and adversely affected the growth rate of lambs on the natural pastures.

As supplementary grazing did not affect production per ewe, the carrying capacity and productivity of an area in this semiarid environment can be calculated on the basis of the proportion of lucerne available if the carrying capacity and productivity are known for the two pasture types when grazed separately. For production per head to be increased it was concluded that a more intensive method of unilization of the supplementary grazing area is required but that such a system may not have practical relevance.

Key words: lucerne, supplement, sheep, grazing, natural pastures, semiarid.

12-3-5

Verano Stylo in the Semi-Arid Northeastern Thailand

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Stylosanthes hamata cv. Verano was first introduced to Thailand in 1975. In the Northeastern part of the country where the climate is marginal and the soils are low in fertility Verano appears to be one of the most suitable forage legumes used in pasture improvement programs.

Verano can be grown satisfactorily on most soils in the Northeast. Oversowing the seed at 3.1 $kg.ha^{-1}$ on unploughed areas resulted in a density of 5-30 $plants.m^{-2}$ while in cultivated land the same amount of seed gave 20-45 plant m^{-2}. In a three-year experiment under different seeding rates and cutting intervals Verano outyielded three commercial cultivars of *S. humilis* and *S. guianensis* more than two-fold. Its dry matter yield averaged over 5 ton ha^{-1} yr^{-1} and its competitive ability with natural weeds was high, permitting only 6-12% (by weight) in most plots after the first year of establishment. It also persisted well under heavy stocking rates (2.5-4.5 A.U. ha^{-1}) compared to other forage legumes.

The highest seed yield recorded for Verano grown in experimental plots was 1,200 $kg.ha^{-1}$ of podded seeds while under normal practice the average Verano commercial seed production in the Northeast was 900 $kg.ha^{-1}$ with at least 90% seed purity. Heavy grazing could be imposed on Verano seed production plots with no reduction in seed yield providing grazing was terminated before soil moisture became limiting.

Verano has been affected by anthracnose disease (*Colletotrichum gloeosporioides*) but the damage was not serious. However, new accessions of this species are being evaluated for higher yield and better agronomic characters.

Key words : *Stylosanthes hamata* cv. Verano, forage legume, establishment, seed production, anthracnose disease, accessions.

12-4-1 Animal Production from Brazilian Tropical Pastures

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This review deals with the potential of beef production from nitrogen (N) and legume-based pastures in Brazil. The tropical Brazilian climate has a wide range of variation, such as A and B types with r and w regimes. C and D climates, including subtypes d and s are met in the NE of the country (Thornthwaite). Monsoonal rains predominate and temperatures below 15°C are common in the central-southern part.

Possibilities for improving the beef industry are very promising when based on grass-legume pastures. Beef production from N fertilized pastures has been shown in Brazil since the sixties. Heavy dressing of N (200/kg/ha/year) produced up to 700 kg liveweight (LWG) gain, using 44 to 100 kg N/ha/year, average LWG was 488.4 kg/ha/year (mean of 12 data). Legume-based pastures gave an average of 344.2 kg/ha/year of LWG (mean of 46 data). The annual rainfall for 29 localities, out of 37 mentioned, ranged from 2,017 to 750 mm, with an average of 1,367 mm. For the 33 experiments where fertilizer was applied, the average of P_2O_5 (basal application) was 93.25 kg/ha, most of it as single superphosphate. In the 37 citations K_2O was used 14 times (av. 49 kg/ha), limestone 10 times (1,700 kg/ha), molybdenum 4 times (0.25 kg/ha), and zinc once (8 kg/ha). Seven of the experimental areas have the following declivities: 2 places between 20 and 30%, 3 places between 14 and 19%, and 4 places with 10.5%. Soils were poor, in general, 19 of them being from cerrado (savanna like) experimental areas.

Grasses used belong to the genera Melinis, Hyparrhenia, Panicum, Cenchrus, Digitaria, Setaria, Brachiaria, and Pennisetum; and for the legumes, Macroptilium, Centrosema, Glycine, Stylosanthes, Leucaena, Galactia, Calopogonium, Pueraria, and Cajanus.

Animals used were zebu cross, with dominance of Nelore breed; in some few cases zebu X holstein steers were used. Results are also presented for LWGs for she-goats, and ewes of a local woolless ecotype which are economically important for meat and hide in the arid, semiarid Brazilian northeastern pastures.

Grazing systems varied from continuous set stock, and continuous put and take, to rotational set stock, and rotational put and take. Stocking rates varied from 4.07 (Napier, 150N/ha/year) to .2 head/ha/year (M.minutiflora, unimproved); average for 17 experiments was 1.7 head/ha/year. For some experiments stocking rates were measured as A.U. (1 animal unit = 400 kg liveweight).

High rainfall regime, and high level of basal phosphate used, plus locally adapted grasses and legumes, explain the good LWGs obtained.

Key words: tropical grasses, tropical legumes, liveweight gains, goats, sheep, cattle.

12-4-2 Herbage Production and Fodder Problems in India

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The Indian mainland is comprised of 3 well-defined regions, namely, the great mountain zone in the north, Indo-Gangetic Plains and southern peninsula. Geologically, the Himalayas are sedimentary, the Indo-Gangetic Plains are a great alluvial tract, the peninsula is a region of relative stability mostly consisting of metamorphic hills, and Gondwanas and basalt (Deccan trap) are overlain in Central India. The climate of India is tropical monsoonic and seasonal. Latitudinal extent and physical features intergrade to provide a variety of climates from extreme hot arid to very humid. Generally, it is a well-drained country. An agricultural census, just completed, gives the land utilization pattern, in million ha: agriculture, 164; forests, 65; non-agricultural use, 16; barren and uncultivable, 32; permanent pastures and grazing lands, 13; and cultivable waste and fallow lands, 32.

Potential aboveground net primary productivity (ANP) in India will not average 5 t/ha/yr which is the figure for a highest productive semi-natural grazing land in a semi-arid tract. If we suppose that only herbage is produced in the entire available geographical area, the total herbage production will work out to 1,904 million t/yr. A normal animal unit consumes on an average 7 t/yr; this figure multiplied by the 344 million live-stock in the country gives a total need of herbage alone for the country of 2,408 million t/yr. It is obvious, therefore, that there is an acute fodder shortage in India.

In the otherwise woodland country, the extensive semi-natural grazing lands (or savannah), occupying a total area of 77 million ha (inclusive of cultivable and uncultivable waste), owe their origin to deforestation and abandoned cultivation, and are maintained at various successional levels. Summer monsoon is the active growth period. There are no seeded pastures nor any practice of putting livestock in paddocks. On the basis of dominance and apparent similarity of physiognomy, the grazing lands can be classified into 6 main types varying in topography, life form and aboveground (ANP) and belowground net production (BNP). The potential production has been accurately predicted from simple climatic parameters and soil factors. Water in the arid zone, pattern of land utilization in semi-arid tract, and low nutrition of herbage in humid areas are the key problems of the Indian grazing lands vis-a-vis the large low-milk-yielding cattle population. Beef is eaten but by a very small section of the society.

Key words: natural grazing lands, aboveground net production, belowground net production, grazing land types, potential fodder production, arid zone, semi-arid zone, monsoon.

12-4-3 Sown Grassland as an Alternative to Shifting Cultivation in Lowland Humid Tropics

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Agriculture based on existing forms of shifting cultivation will not be able to adequately support and feed the rapidly increasing human population of low-land humid tropics of Africa. The forest and natural fallows have shortened and even disappeared in some areas because of rising food demands. Crop yields are low and continue to decline. What then are the alternatives?

Using Cynodon as an example, an attempt is made to show that mixed farming offers an alternative whereby the nutrient status and physical properties of the soil can be maintained, erosion checked, weeds kept under control and the build-up of pests and parasites minimized or avoided.

A synthesis of several years of intensive breeding and agronomic research at the University of Ibadan indicates:

1. Availability of improved robust, nonrhizomatous Cynodon genotypes with an annual DM yield potential of around 15t/ha, adequate for production of 650kg/ha of liveweight gains by the local Zebu cattle when grazed from April to December.
2. Annual nutrient mobilization of over 122,25,175,37 and 29kg/ha of N,P,K,Ca and Mg respectively by Cynodon pastures. Around 20% of the nutrients mobilized are 'pumped up' from soil layers below 30 cm
3. Possession by several Cynodon genotypes of high microbial population in the rhizosphere capable of fixing varying quantities of N. IBX-7, an improved hybrid is able to fix upto 2 kg/ha of N per week.
4. Significant increase in soil organic matter under temporary Cynodon pastures, replenishing a high proportion of the substantial loss of 63% in OM under 10 years of continuous cultivation.
5. Improvement of soil physical properties under Cynodon pastures as measured by soil aggregate size and aggregate stability, bulk density, and total porosity.
6. Cynodon, when fully established, gives almost as much protection against erosion as does forest with closed canopy. On a soil with 3% slope water runoff from Cynodon plots was 5.3% of the total erosive rain of 155cm. Soil losses under pasture during the growing season were less than 10% of those observed in maize and cowpea plots.
7. Root exudates collected from several Cynodon improved genotypes when placed with seeds of common tropical weed species inhibit germination or reduced seedling growth. Aqueous extracts of Cynodon roots show similar inhibitory effects. The inhibition factor disappears after 27 to 45 hours of storage.
8. Resistance of Cynodon genotypes to the root knot nematodes (Meloidogyne spp.). Growing of Cynodon in highly infested soils decreased the root knot nematode population appreciably in six months and eliminated the nematodes completely within 18 months. Consequently tomato yields increased by about 300 percent.

Hopefully some of these findings will benefit those engaged in tropical farming systems research.

Key words: Cynodon, shifting cultivation, mixed agriculture, soil physical & chemical properties, allelopathy, nitrogen fixation in rhizosphere, pest control.

12-4-4

Insect Pests of Tropical Forage Plants in South America

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The objectives of this continuing research work are to make a general survey of the insect populations occurring on tropical forage plants in five countries in South America and to identify the most important pests.

To realize this investigation, pure stand plots 5 x 5 m were sampled every 14 days during two years using an D-Vac. Vacuum Sampler.

The following information was obtained:

(a) Most important families and/or genera of insects in tropical forage legumes and grasses.
(b) Insect group frequency for each season.
(c) Insect group frequency for each plant ecotype under study.
(d) Preliminary data on insect preference.
(e) Preliminary data on relationships between insects on forage plants and viral fungal and bacterial diseases.
(f) Most important pests of tropical forage plants in South America.

These important pests of tropical forage legumes include: stemborer (Caloptilia sp.), leaf-hoppers (Cicadellidae-several genera) and leaf-eating beetles (Crisomelidae-several genera). Chinchbugs (Pentatomidae, Lygaeidae) and sucking planthoppers (Membracidae) are under investigation as disease transmitters while seed-eating beetles (Curculionidae) and budworm (Stegasta bosqueella) reduce seed production. In grasses, spittlebug (Zulia, Aeneolamia and Deois spp.) causes serious damage and seed-feeding leafhoppers (Cicadellidae) reduce seed production.

This on-going research has provided and is continuing to provide valuable and essential information about the most important insect pests, pests of secondary importance, potential pests and beneficial insects of tropical forage plants in five different countries in South America. This is the first complete study of the insect fauna of tropical forage plants and herein lies its importance and significance.

Key words: insect pests, tropical forage plants, South America.

12-4-5

Some Initial Results of Field Trials Conducted in Establishing a Pasture Seed Industry in Cojedes State Venezuela

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In starting a pasture seed industry on a farm located at 9°50'N latitude and which gets about 1600 mm of rain yearly followed by a severe dry season from mid-December to April, 4 widely separated sites were selected to plant 3 grasses for commercial seed production in 1978. The objectives were to assess the fertility status of the soils, then determine the fertilizer requirements of the grasses at each site, and establish an introduction garden with 70 cultivars of grasses and legumes to study their suitability for expanding seed production.

Based on the results of soil analyses, a modified missing element technique was used to test the effects of 7 plant nutrients in a field trial with 10 fertilizer treatments in 4 randomised complete blocks at each of the 4 sites (2 with *Panicum maximum* cv. Colonial, and 1 each with *Brachiaria humidicola* and *Brachiaria decumbens*). A replicated factorial experiment testing nitrogen (N) and phosphorus (P) at 3 levels was also put down with Colonial at one site. In the second year, 12 grasses were planted in 4 randomised complete blocks to obtain forage yields and observe their acceptance by cattle.

Although the soil tests indicated that several plant nutrients might limit seed production, the results of the fertilizer trials showed a highly significant response only to P treatment at all 4 sites, and a significant response to N treatment at only 1 site in the first year. In the second year, spittlebug (*Aeneolamia reducta*) first appeared in *B. decumbens* only, and in 1980 this pest attacked all the introduced grasses except Colonial; fortunately, commercial seed yields were not seriously affected. *B. humidicola* though attacked by spittlebug recovered quickly, and is regarded as the most outstanding grass introduced so far, with the potential to revolutionise Venezuelan pasture development. Cultivars of *Andropogon gayanus*, *Brachiaria brizantha*, and *Setaria anceps* appeared promising for future grass seed production, also certain cultivars of legume species, notably *Leucaena leucocephala*.

It has been conclusively shown that P fertilization is essential for pasture establishment and productivity; other nutrients are also low in availability and are being studied. Control of spittlebug is now necessary to prevent its increase, and possible damage to grasses before seeding. A great potential exists for forage seed production that can immensely benefit pasture improvement in Venezuela.

Key words: seed production, field trials, phosphorus, spittlebug, Venezuela.

12-5-1 Natural Grasslands in the Thai Highland: Limitations to Cattle Productivity

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Increasing cattle production in the highlands of northern Thailand is one part of improving the income of subsistence farmers and providing an alternative to opium production. Imperata cylindrica (L.)Beauv. is the principle grassland species in the region and is a major component of the diets of highland cattle. Four studies were conducted which aimed to determine factors limiting cattle production on native grasslands.

The rate of dry matter production after the annual pre-wet season wildfires, the rate of regrowth after successive cuttings and the nitrogen content, phosphorus content and in vitro digestibility of Imperata cylindrica were studied. Dry matter production was slower than that recorded elsewhere in the tropics, and nitrogen content and in vitro digestibility were correspondingly higher for a longer period. Altitude probably limited growth rates through lower temperatures and maintained quality of Imperata above maintanance for at least four months.

Fourty-one species grazed by cattle were identified and ten of the most commonly selected species at different times of the year were analyzed for in vitro digestibility, nitrogen, phosphorus and sodium content. Levels for in vitro digestibility, nitrogen and phosphorus were low only during the dry season while sodium levels were low throughout the year. Additional research confirmed a sodium deficiency in cattle grazing these pastures.

The nitrogen and phosphorus contents of the faeces of cattle grazing native highland grasslands were determined for 150 samples. Both nitrogen and phosphorus levels were higher than would be expected from animal productivity data thereby confirming the action of other limiting nutrients.

Oesophageally fistulated cattle were utilized to determine the quality of feed selected by free range cattle in the highlands. In vitro digestibility and nitrogen analyses indicated that pasture quality may limit productivity in the dry season. Bite rate and size indicated that total intake of forage would also be a limiting factor. Further data of faecal output confirmed that feed intake was insufficient (1.3% of liveweight per day) during the wet season and the hot dry season but not during the cool dry season.

Limitations to cattle production from native highland grassland in Thailand are related to specific mineral deficiencies including sodium, and to insufficient feed intake.

Key words: Imperata cylindrica, pasture quality, cattle mineral deficiency, feed intake, digestibility, Thailand.

12-5-2

Pasture Research and Development in the Highlands of Northern Thailand

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The northern Thai highlands constitute the most accessible area of the "Golden Triangle" which produces most of the World's illicit opium. This paper summarises most of the improved pasture agronomic research and development that has been undertaken in this area over the years 1972-9. In addition the ecology of the grasslands is discussed.

The objectives were to determine viable means of rehabilitating Imperata cylindrica grasslands that result from opium growing and to assess the potential of beef cattle production on improved pastures by tribal inhabitants as a viable alternative to opium growing

The Program had three stages viz. basic agronomic research, establishment of demonstration pastures in selected highland villages, and development of pilot extension projects.

The best adapted legumes were Desmodium intortum cv. greenleaf, D. uncinatum cv. silverleaf, Macrotyloma axillare cv. archer. The best adapted grasses were Panicum maximum cvv. hamil, green panic, trichoglume; Setaria anceps cvv. kazungula, nandi and Brachiaria decumbens.

On most soils both phosphorus (P) and sulphur (S) fertilizers were required for successful establishment of pastures. Research led to the recommendation of applying the local sources of fertilizer at establishment: 100 kg P as rockphosphate + 20 kg S as gypsum/ha.

Establishment of legumes into grasslands was readily accomplished by heavy grazing or slashing following a dry-season burn just before oversowing in early wet-season. A small breeding group of unsupplemented local cattle (yellow Asian) on D. intortum dominant pastures produced an average 182 kg liveweightgain (LWG)/ha/yr over 4 yr at 2-3 adult equivalents (AE)/ha with the breeders on the pasture (1 AE=200kg liveweight). Legume pasture was persistent over this period although legume plant density declined if seed set was not allowed for three years. An equivalent herd on unfertilized legume pasture averaged 86 kg LWG/ha/yr at 1 AE/ha; weed invasion was rapid in this pasture.

Legume pasture significantly increased yields of following crops; grain yields of unfertilized maize were increased from 0.7 to 1.35 t/ha.

Pilot extension projects of beef cattle on improved pastures conducted by tribal inhabitants were satisfactory so long as credit and Project direction were provided.

It is suggested that a viable highland agricultural system for I. cylindrica grasslands is ley farming (2 year pasture - 2 year upland crop rotation) integrated with beef cattle production and pasture seed collection for export. For a 5 ha farm, total cash costs for a 6 yr project are $1,850 and total returns $3,380. The major cost is the purchase of the herd. Abandoned opium fields may be cheaply rehabilitated by oversowing with legume and fertilizer.

There has been little adoption of improved pastures following termination of the Project. It is suggested constraints to adoption include: comparatively high cash expenditure required to establish an enterprise, lack of knowledge and skills in northern Thailand of establishment and management of improved pastures, traditional non-commercial attitudes to livestock raising by tribal people and the continuing ease and profitability of opium growing.

Key words: pioneer pasture research; Thai Highlands; cattle; ley farming.

12-5-3 Aspects of the Legume-Grass Balance of Greenleaf *Desmodium setaria* Pastures in the Highlands of Northern Thailand

A.C. Andrews

The aim was to study changes in the botanical composition of pastures based on mixed *Desmodium intortum* cv. Greenleaf and *Setaria anceps* cv. Nandi under simulated cut and carry management.

Three experiments were carried out between 1976 and 1979 at Pa Kia (19°N, 99°E, elev. 1,500m), Northern Thailand, a site with tropical monsoon climate modified by altitude. All experiments involved a cut and regrowth technique in which the plots were cut at a height of 15 cm every six to eight weeks. Standard randomised complete block designs were used. Samples were separated into grass, legume and weed components, dried and weighed. The experiments continued for two to four years.

In experiment 1, Greenleaf and Nandi seed, each at 0.5 kg/ha, was broadcast onto lightly chipped plots. In experiment 2, Nandi sprigs were planted into an established Greenleaf sward at a spacing of 50 cm x 50 cm, as part of a trial involving Greenleaf and several grass species. In experiment 3, Nandi sprigs were planted into a Greenleaf sward at densities of 0, 1, 2 and 4 sprigs m^{-2}. In all experiments the plots were topdressed with phosphorus and sulphur fertilizers.

In experiment 1, total edible dry matter yields in the first and second years were 2.6 and 5.8 tonnes/ha. The legume fraction declined from 68 percent in year 1 to 34 percent in year 2. In experiment 2, total edible yields for the first three years were 6.0, 11.1 and 7.2 tonnes/ha, compared with 5.2, 6.0 and 4.8 tonnes/ha, respectively, for the pure Greenleaf sward. The legume content of the mixed sward fell from 75 percent in year 1 to 26 percent and 17 percent in years 2 and 3. In experiment 3, grass yields increased in proportion to sprig density, ranging from 0.5 (0 sprigs m^{-2}) to 1.5 tonnes/ha (4 sprigs m^{-2}) in year 1, and from 0.8 to 6.4 tonnes/ha in year 2. Legume yields of all treatments were similar (4.3 tonnes/ha) in year 1, but in year 2 ranged from 4.2 (0 sprigs m^{-2}) to 1.8 tonnes/ha (4 sprigs m^{-2}). Nitrogen yields (in harvested plant tops) increased in proportion to sprig density in year 1, but in year 2, maximum nitrogen yield occurred in the treatment with 2 sprigs m^{-2}. Weed yields declined as the grass sprig density increased.

The incorporation of Nandi Setaria into Greenleaf Desmodium swards will increase the total dry matter production, suppress weeds, and in the short term may also increase nitrogen yield of plant tops. However, in the long term, there is a trend towards grass dominance which will eventually lead to reduced productivity and a decline in forage protein content. In a cut and carry system, this trend could be alleviated by planting sprigs of the grass into pure Greenleaf swards at wide spacings (one to two sprigs m^{-2}), and by selectively cutting a greater portion of the grass at each harvest.

Key words: grasses, legumes, grass/legumes, yield.

12-5-4 A Promising Technique for Improving Steep Infertile Natural Pastures

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Over 15,000 hectares of rolling terrain in the intermediate rainfall (1700 mm) lower montane zone (1500 m) of Sri Lanka, comprising infertile natural grassland known as "dry patanas," have been recommended for development into pastures. Two approaches have been previously tried but both have their limitations; therefore, an alternative technique is needed.

The objectives of this experiment were to determine whether an economically feasible, minimum tillage technique could be devised and to select tropical pasture legumes which could be established and managed for soil amelioration, during the development phase.

One ha of representative hillside with a 40° gradient was divided into 3 blocks. Contour bench terraces were constructed, alternating with strips of natural grass. A 0-8-10 corrective fertilizer mixture was banded at the rate of 180 kg/ha, and legume seed dibbled along the angle formed by the terrace and embankment, under the protection of the natural grass canopy. In October 1976, terraces were sown with each of the following legumes: greenleaf desmodium (Desmodium intortum), silverleaf desmodium (Desmodium ucinatum), Siratro (Macroptilium atropurpureum), Hamata stylo (Stylosanthes hamata), Endeavour and Cook stylo (Stylosanthas guianensis) cultivars.

All seedlings established well and had good nodulation. At 6 months the plant height, length of tap root and laterals ($\bar{x} \pm$ SD) of greenleaf desmodium were 37 ± 1.32, 05 ± 0.51, and 30 ± 1.25 cm, respectively. Nodulation was good with 15 ± 1.26 large healthy nodules per plant. Stylosanthes species attained a height of 15 ± 1.26 cm. After 1 year, greenleaf desmodium showed the best growth, having almost 100% ground cover canopy in the terraces, with a good build-up of leaf litter and yielding one seed crop. The Stylosanthes species as a whole developed at a slower rate and had a 75% ground cover. Silverleaf desmodium and Siratro made only sparse growth. Both greenleaf desmodium and Stylosanthes species withstood the 4-month dry period and dessicating winds. They also invaded the grass strips on higher ground. From the third year onward the pastures were regularly utilized, by harvesting twice, grazing once by sheep, and by taking one seed crop per annum. Dry matter yields ($\bar{x} \pm$ SD kg/ha/an) were: greenleaf desmodium 2,551 ± 30, Hamata stylo 2,238 ± 27, Endeavour and Cook stylo 2,125 ± 28. The phosphorous, potassium, organic matter and soil pH values increased from 05 ± 02, to 64 ± 04 (avail. P_2O_5 kg/ha), 0.05 ± .09 to 0.41 ± .08 (exch. K me/100g) 1.86 ± 01 to 2.97 ± .09 (OM%) and 4.8 ± .3 to 5.6 ± .2 (1:1 pH), respectively.

It is concluded that greenleaf desmodium and Stylosanthes species can be successfully established in a difficult environment. These legumes build up soil fertility and also improve the feeding value of natural grassland. This technique seems to be more advantageous and economical than previous methods and could be adopted for improving the animal industry in this region.

Key words: soil amelioration, erosion, natural grass canopy, Desmodium stylosanthes.

12-5-5 Introduction and Management of Forages in the Highlands of Guatemala

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The Guatemalan Highlands comprise about 2 million ha of land between 1500 and 3600 m elevation. Mean annual rainfall ranges from 800 to 1500 mm and occurs in most of the area between early May and November. The average monthly maximum temperature varies from less than 15° C to about 28° C, depending on altitude and time of the year. Night-frosts occur in the dry season and are severe in the higher valleys. Most of the land is owned by Indian small-holders who grow principally corn, wheat and potatoes. Large numbers of cattle, sheep and goats are herded in the vast, often communal, natural grasslands and forests and on roadsides, fallow land and crop residues. Animal production is low because of poor nutrition and management; overgrazing causes serious deterioration of the natural vegetation and accelerated soil erosion. The objective of this research was to introduce productive forages into the different ecological areas of the Highlands. The research was carried out between 1970 and 1978 under 2 pasture and livestock development projects executed by the Guatemalan Ministry of Agriculture with assistance of the Food and Agriculture Organization of the United Nations.

Evaluation of the adaptation and productivity of a large number of forage species was carried out as follows: Small screening experiments were established to observe the performance of the species in different ecological areas. Some replicated experiments were carried out to estimate production and quality of promising species and to compare varieties, fertilization levels and cutting frequencies. The best yielding forages were sown on experimental farms and studied under farm management.

Subtropical grasses outyielded temperate grasses in the lower areas and the reverse occurred above 2200 m. Pure stands of grass gave a poor yield without applied nitrogen (N) and responded highly to N-fertilization. On acid soils liming and inoculation of the seeds were required for establishment of legumes. Alfalfa (*Medicago sativa* L.) gave annual dry matter yields of 12.000 - 18.000 kg/ha on good soils (without irrigation) up to 2600 m elevation. With irrigation in the dry season, even higher yields were obtained with mixtures of Italian ryegrass (*Lolium multiflorum* Lam.) and white clover (*Trifolium repens* L.). Other promising species were orchardgrass (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* Schreb.), red clover (*Trifolium pratense* L.) and subterranean clover (*Trifolium subterraneum* L.). The persistence of unirrigated pastures was found to be insufficient in areas with heavy night-frosts and soils with a low moisture-holding capacity.

It was demonstrated that several introduced forage species produce high yields of good forage in the Guatemalan Highlands. They can be used to improve animal production and to reduce grazing pressure on the natural vegetation.

Key words: tropical highlands, Guatemala, forage introduction, forage yield, *Medicago sativa* L., *Lolium multiflorum* Lam., *Trifolium repens* L.

12-6-1

Potential of *Aeschynomene* Species for Pastures in the Tropics

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The objectives of this study were: to assess the forage potential of readily available world germplasm of the genus, *Aeschynomene*, which comprises 160 species; to compare some attributes of the commercial American jointvetch (*Aeschynomene americana* L.) with those of other accessions of the same, and other species; and to compare the seasonal growth pattern and response to phosphorus (P) of commercial jointvetch with two perennial tropical legumes.

Evaluations were made of 342 accessions including 25 identified species. Data collected from observational plots in 1978 and 1980 included initial flowering dates, plant vigor and growth habit; from replicated plots, plant populations and vigor; and from selected accessions, yield, nitrogen, and digestibility. Comparison of yields at 20 and 60 kg/ha of P (2000 kg/ha of lime) was made between jointvetch and Siratro (*Macroptilium atropurpureum* Urb.) and 'Florida' carpon desmodium (*Desmodium heterocarpon* L.).

A majority of *A. americana* accessions flowered after 1 October and height distribution from less than 51 cm (18 accessions) to greater than 152 cm. Thus it should be possible to select a later flowering and more leafy plant than the commercial jointvetch. *A. villosa*, similar to but with shorter stems than *A. americana*, appeared to have potential for grazing. *A. denticulata*, *A. falcata*, *A. elegans*, *A. evenia*, *A. fluitans*, and *A. paniculata* warrant further study, although establishment and persistence when grown with *Digitaria decumbens* Stent. was not always good.

In June crude protein content of commercial jointvetch (18.8%) was highest and digestibility among the best (52.1%) when compared with other accessions. These values ranged from 10.6 to 18.8% and 36.8 to 63.8%, respectively, among the accessions analyzed.

Establishment year production of commercial jointvetch was better than Siratro and carpon desmodium, but was much less in June the subsequent year. Yield response of jointvetch to 60 kg/ha of P was greater than that for carpon desmodium when compared with 20 kg/ha.

Key words: *Aeschynomene*, jointvetch, evaluation, yield, growth habit, flowering dates, quality.

12-6-2 Yield and Quality of Tropical Legumes During the Dry Season: Galactia striata (Jacq.) Urb.

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A small plot experiment was conducted during two consecutive years, in the "cerrados" of Brazil, to evaluate the effect of four dates of deferment (Feb. 21, March 7 and 21, and April 4 respectively) on the rate of growth, chemical composition and in vitro dry matter digestibility (IVDMD) of a pure stand of Galactia striata, a naturalized legume. The choosen dates of deferment embraced the last two months of the rainy season. Yields were estimated at intervals of 28 days, over an experimental period of 237 days, ending with the beginning of the following rainy season. Asymptotic growth was observed throughout the experimental period. Yields during the critical August/September period varied between 1000 and 5000 kg dm.ha^{-1}, depending on treatment and year. Differences in yield between treatments and years were accounted for, largely by differences in accumulated rainfall and maximum temperature, as indicated by regression analysis. The contribution of leaves to dry matter yield decreased from an initial 75%, to about 35% at 168 days of age. This decrease was treatment-independent and strongly age-dependent. During most of the dry season, CP averaged 15% in the standing herbage; no treatment effect was noted when compared at the same age. CP in leaves decreased from 32% at 28 days of age, to about 20% at 112 days, and remained constant thereafter; in the stems, CP was 15% initially, and stabilized in 10% at 84 days. The IVDMD of the available forage fell very slowly during the dry season; in the most critical period it varied between 55 and 60%. In leaves, the IVDMD fell initially, but soon stabilized around 65% at 56 days. Seed production was observed in the earliest dates of deferment, and amounted to up to 280 kg.ha^{-1} of pods.

It was concluded that Galactia is capable of providing high quality forage during the dry season, while its yield depends mainly on the precipitation and temperature accumulated after the date of deferment.

Key words: Galactia, Galactia striata (Jacq.) Urb., yield, deferment, dry season, nutritive value.

12-6-3 Effect of Maturity of Four Cultivars of Pennisetum purpureum Schum on Production and Nutritive Value

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Two cultivars, Vruckwona and Cameroun from Zaire, Africa, were comparatively studied with 2 cultivars, Mineiro and Taiwan A-144, for quantitative and qualitative aspects in Botucato (latitude 22° 52' S, longitude 48°27' N, altitude 810 m), Sao Paulo, Brazil. The climate is tropical and humid. During the experiment the minimum and maximum average air temperatures were 16.8° and 26.8° C, respectively, with 1,372.6 mm rainfall. The soil is aluvial. The experimental area was maintained under optimum fertilization. After the uniformity of the stand, 4 cuts were made at 45-days intervals at 2 heights, 0.20 and 0.40 m. At time of cutting dry matter (DM) and crude protein (CP) were determined for each cultivar. The levels of ether extract (EE), crude fiber (CF), ash (A) and nitrogen free extract (NFE) for each cut were also determined, as well as the components of the cellular wall. Photocolorimetric methods were used for determination of phosphorus (P) levels and atomic absorption spectrophotometric methods were used for Ca, Mg, K, Fe, Zn, Cu, and Mn determinations. In vitro digestibilities were also determined. There were no significant differences in DM and CP productions among cultivars though production averaged higher for Taiwan A-144, the average being DM=17,272.03 kg/ha and CP=1,610.22 kg/ha. Significant differences ($P<.01$) were observed for cut and height effects. There were no significant differences among cultivars in DM, CP, EE, CF, A and NFE levels. However, the Mineiro CP level was higher than the others (11.66%) as was the Taiwan A-144 CF level (35.36%). There were significant effects ($P<.01$) among cuts for all characteristics considered and between heights of cuts there were significant differences in DM ($P<.01$) and EE and CF ($P<.05$). The difference between cultivars was not significant for neutral detergent fiber, cellular content, acid detergent fiber, cellulose, hemicellulose, lignin or silica. Cameroun and Taiwan A-144 had higher levels of cellular content (33.52%) and cellulose (34.56%). There was a significant difference ($P<.01$) among cultivars in in vitro DM, digestibility being higher for Cameroun (45.85%). There was a significant difference among cuts ($P<.01$) but not for heights. Among cultivars there were significant differences in P, Zn, Cu and Mn ($P<.01$) and Fe ($P<.05$) levels but not for K, Ca and Mg. Among cuts there were significant differences ($P<.01$) in levels of all the minerals while between heights the differences in P and Fe levels were significant ($P<.01$).

Key words: pennisetum, cutting frequency, cutting height, composition, digestibility.

12-6-4

Hemarthria altissima, a Pasture Grass for the Tropics

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Limpograss, (*Hemarthria altissima* (Poir) Stapf et C. E. Hubb), introduced into the United States in 1964, has been evaluated for use as a pasture grass. Under Florida conditions it has shown yield potential equal to or greater than other tropical pasture grasses and often has greater cool season yields than bermudagrass (*Cynodon dactylon* L.) or digitgrass (*Digitaria decumbens* Stent.). The cultivar 'Bigalta' has higher *in vitro* organic matter digestion (IVOMD) than other tropical grasses at comparable growth stages. Early evaluations of limpograss involved only three clones, but additional genotypes were collected and introduced during the late 1960's and early 1970's and an evaluation scheme for this germplasm was undertaken.

Our objectives were to rapidly evaluate the available germplasm of limpograss for genetic diversity in traits of importance as a component of a forage livestock system, to compare clipping and grazing as evaluation techniques, and to select superior genotypes for animal performance experiments.

Following perliminary testing of 53 clones in greenhouse and small plot clipping trials, 22 clones were selected for evaluation by clipping, and 27 by grazing. Both methods of defoliation were at 5 week intervals. A wide range in genetic diversity for yield, persistence, and forage quality was observed. After one season under clipping, persistence ranged from 12 to 86%. Greater winter stand loss was observed with grazing defoliation than with clipping, and by the autumn of the second year some genotypes were eliminated. Others yielded from 2,800 to 15,800 kg/ha and IVOMD ranged from 56 to 73% for 5-week regrowth forage.

Eight genotypes selected from these experiments were then evaluated at four frequencies of grazing defoliation (3, 5, 7, and 9 weeks) in a third experiment. Persistence was poorest at the 3-week grazing frequency. Total seasonal yields were similar at the 5 and 7-week grazing frequencies. The tetraploid genotypes 'Bigalta' and P.I. 364888 had markedly higher yields at the 5 and 9-week grazing frequency. P.I. 364888 was generally the highest yielding entry at all grazing frequencies and was not significantly lower in IVOMD than Bigalta. Bigalta was significantly lower in persistence at the 5 and 7-week rest interval than P.I. 364888.

Over 50 introductions have been evaluated under clipping and grazing and one genotype has been selected for advanced animal evaluation. This evaluation scheme required about six years to identify genotypes which are superior under grazing.

Key words: limpograss, *Hemarthria altissima* (Poir) Stafp et C. E. Hubb, forage evaluation, forage quality.

12-6-5

Growth Curve and Nutritive Value of Forage Sorghum in the Tropics

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A field trial located in the region of the "cerrados" of Brazil, was carried out to study the growth curve and nutritive value of forage sorghum under tropical conditions. A commercial-type planting of Sorghum bicolor cv. BR 610 was used. The crop was sampled at intervals of 14 days, beginning at 63 days of age, and until 238 days, well into the dry season. The growth curve was fitted with a second degree polynomial; a maximum yield of 17 tons d.m. ha^{-1} was attained between 140 and 150 days of age, followed by a decrease due to physical losses of plant components. Dry matter percent increased initially, and it reached 30% at about 120 days; thereafter, it remained nearly constant until the end of the experiment. Fractionation of plants into their components showed that with increasing maturity there was a marked loss of green leaves, which decreased from 58% at 63 days to 10% at ensiling time. Stems plus sheaths increased with advancing age from an initial 43%, and plateaud at 70% at about 108 days. The maximum contribution of heads was 20%, with a ratio of grain:raquis of 2:1. Crude protein in the crop decreased with increasing age until 123 days, after which it stabilized in 3-4%. Green leaves and heads were 3.5 times higher in CP than stems. The in vitro dry matter digestibility of the crop decreased initially from 68% at 63 days, to about 65% at 108 days, followed by a sudden rise to 73% at 123 days of age, which coincided with maximum accumulation of non-structural carbohydrates and a high content of heads. Thereafter, the drop in digestibility averaged 0.25 units/day, in the period of 123 to 238 days of age.

It was concluded that sorghum grown under tropical conditions has a high yield potential and is of relatively good quality, although its protein content may be seriously limiting.

Key words: forage sorghum, Sorghum bicolor (L.) Moench, yield, crude protein, digestibility, components ratio.

13-1-1 Techno-economic Analysis for Rangeland Development in Arid to Semi-arid Regions of Western India

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Western India, in general, is an arid to semi-arid region. It is almost a flat sandy country constituting the Great Indian Desert with an area of about 29.5 million ha, human population over 10 million and livestock population over 14 million. In this tract much of the economy depends upon animal husbandry. Cattle, sheep, goats and camels largely constitute the livestock population. Regular paddocks are not maintained in this country and livestock is permitted to graze indiscriminately on open lands. The grazinglands are low in both carrying capacity and nutritive value. Over-exploitation has not only decreased their productivity, but is continuously bringing about loss of fertility and soil erosion. Large-scale migration of livestock takes place every year, during summer months, from this region in search of fodder and forage. Only 11% of the total desert area is utilized for crop culture; 17.7 million ha of land is lying as barren, uncultivable degraded land which is put to open grazing. About 60% of such land is private land and is in possession of farmers.

An important need in the desert areas is the preservation of organic matter for soil. Thus to support increasing livestock population and to improve the degraded lands, development of rangelands on large areas including private lands needs to be promoted. Minimum size of the plot to be developed into pasture on private land should be so decided that it can serve as an economically viable unit.

Pasture development operations include protection of the plot through fencing, adoption of soil-and water-conservation measures, land preparation, fertilization, rodent-control measures, introduction of nutritive and palatable grasses like Oenchrus ciliaris and Lasiurus sindicus, and the selection of a proper grazing system. In this region it has been observed that the herbage production of 0.4 m ton/ha per year in degraded lands can be increased to 3.0 to 3.5 m ton/ha/year after its full development into rangeland. Generally the development of rangeland on degraded soils takes 2 to 3 years time-period. Carrying capacity of 2 ha area of rangeland is two adult animal units equivalent to two adult cows or buffaloes or 16 adult sheep. Economic analysis has shown that the development of pasture on 2 ha land would serve as an economically viable unit. Benefit-cost ratios for such a plot with two cows or with sixteen sheep have been estimated to be 1.992 and 1.955, respectively. Respective values of internal rate of returns have come out to be 104% and 53%. Therefore, development of pastures on degraded private lands will not only serve in the economic upliftment of the farmers but the process of desertification can also be controlled.

Key words: rangeland, arid, semi-arid, livestock, carrying capacity, benefit-cost ratio, internal rate of return, desertification.

13-1-2

Brush Range Management on the North Coast of California

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INTRODUCTION: A brushland management program to transfer grassland research findings to ranch and range practices and reverse a 25-year trend toward decadent brushfields was initiated seven years ago. It involved the cooperation and coordination of many private land owners and 10 different government organizations.

The Brushland Improvement Program is based upon long-range multi-use research done by the University of California on effects of brush management on soil, water, ground cover, livestock, and wildlife. It involved research using remote sensing techniques and its application in developing brushland vegetation management plans.

OBJECTIVES: This project to manage brushlands involves fuel modification to improve the quality and quantity of forage and habitat for domestic animals and wildlife. It will decrease the hazard of disastrous wildfires and can protect forest products by reduction of fuel and brush. This program will reduce erosion by converting to grass and increasing grass cover on brushlands. The reduction of brush and hardwood cover increases water production, improving conditions for wildlife and fish. The program improves the economic status of the ranch units involved. It provides for maximum public benefits from the land and its resources including recreation.

PROCEDURES: Implementing this range resource program required the active support of the Mendocino County Board of Supervisors and the California State Legislature. Legislation was passed to establish this program as one of two pilot areas in California to demonstrate brush management. It also involves coordinated resource plans between private lands, public lands, and land managers to provide for comprehensive multiple land uses of range resources to benefit all resource users.

On the initial 200,000-hectare pilot area a fuel break system was developed using natural grasslands, vegetation cover, and topography. Fuel modification plans were developed. An atlas of maps and map overlays were provided private and public land owners including maps of geology, soils, vegetation, species composition, property lines, slope and aspect. This atlas was the basis for helping each landowner or manager develop individual vegetation management plans.

RESULTS: This program has resulted in developing intensive long-term range and vegetation management plans. Where soil and slope permit, brushland has been converted to grassland. Decadent brushlands have been treated to develop uneven age stands of brush and increase the annual grass component. Hardwood stands have been thinned to release the grass, and the brush piles provided wildlife cover. Major fuel breaks are being developed clearing brush and seeding grass.

This program brought together all resource users in regular meetings which helped to resolve many land use problems and allowed programs to develop without the barrier of property lines.

CONCLUSIONS: This project is a demonstration of the best management practices for brushland management. It will provide leadership for regional and large scale brush management for the future in California.

Key words: brushland improvement, remote sensing, fuel break system, multiple land uses.

13-1-3 Using Fire to Improve Mixed Prairie

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Use of prescribed burning strictly for the purpose of improving the quality of forage for grazing purposes has been limited on the mixed prairie of north central Texas. An important reason for this is the lack of understanding of the dynamics of mixed prairie and its interaction with fire. The objective of this study was to evaluate plant successional changes and animal responses following a controlled burn near Vernon, Texas.

The burn was conducted in mid-March 1976, on approximately 100ha of mixed prairie rangeland. Sideoats grama (Bouteloua curtipendula), a warm season grass, and Texas wintergrass (Stipa leucothrica), a cool season grass were important mid-grasses, whereas buffalo grass (Buchloe dactyloides) was the dominant short grass. Annual broomweed (Xanthocephalum draculoides), a periodic invader on the mixed prairie, was particularly dense, ranging from 80 to 90 percent canopy cover in 1975. During the winter of 1975-76 the 45 to 63 cm tall dead standing broomweed stalks were noted to cause eye irritation in cattle and hamper grazing. Mature broomweed may persist in an area for over a year and burning effectively eliminated all of this standing litter. The fire was started at about 9:30 a. m. after first providing a 50m backfire buffer strip along the margin of the pasture away from the prevailing winds. The fuel load was about 1130 kg/ha. Air temperature was about 22 degrees, relative humidity 35 percent, and winds a brisk 15-20 km/hr from the south. Soil moisture readings taken prior to and after the burn showed little difference, indicating the fire was relatively "fast" and "cool."

Two months after burning the yield of grasses and forbs was slightly higher on a site not burned (1774 kg/ha), compared to the adjacent burned area (1504 kg/ha). However, production of perennial grasses most preferred for grazing purposes was higher on the area burned. The composition and frequency of major grass species was comparable on the two areas indicating that the fire did not eliminate any key species. Production of desirable perennial grasses one and two years after burning was 59 and 80 percent greater on the burned versus the nonburned area. Japanese brome (Bromus japonicus) and other cool season annual grasses were virtually eliminated for 3 years after the burn. The third year after the fire total yield was significantly higher on the burned area (2103 kg/ha) compared to the nonburned area (1555 kg/ha). Observations taken on cattle grazing patterns indicated a strong preference for grasses in the burned area. Three times more forage was removed and twice as many plants were grazed 2 and 3 years after the fire.

The controlled fire in this experiment showed 3 major benefits, (1) improved production and composition of desirable forage species; (2) removal of mature annual broomweed and control of the undesirable annual grass, Japanese brome; and (3) improved palatability and quality of forage for grazing purposes. The major drawback to burning was the loss in forage supply for at least one growing season. However, this study indicated the loss was regained after one year.

Key words: fire, mixed prairie, production, grazing patterns.

13-1-4 Toward Operational Remote Sensing Information for Two Different User Classes

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The objective of this project was to match a number of potential satellite based remote sensing resource related data products to the appropriate user classes, develop the specific products for that user class and then furnish the product to the user for evaluation and further product refinement.

A group of potential users of satellite based data, including technical groups (Soil Conservation Service, etc.), ranchers, and farm news media, were identified by the project staff. A representative group of each user class was sampled by mail questionnaires or personal interviews about present data sources, methods of making decisions and utility of present data. The respondents were asked to rank a menu of potential information types. Demographic data were obtained to identify the group. Results from responses concerning the menu of potential new data were used to select the information products to be experimentally produced, and for whom.

The experimental data users selected for the product test were several ranchers in cooperation with the Texas Agricultural Extension Service (TAEX) and a state land administration agency which is charged with the wise administration of 2.1 million acres of state property leased to 120 lessees.

The rancher questionnaire results indicated that new satellite based data are desired on two relative scales. One scale is regional and deals with marketing-type information. The other scale is ranch oriented and deals with on-ranch decisions.

For the initial test effort only regional scale data were generated. Several data products were produced and sent to selected ranchers for evaluation, including change in green vegetation over a six week period in the growing season, and rainfall distribution for the same period. Ranchers were asked to make comments as to detail level, format, and understandability of the data products. Approximately 55% of the respondents indicated that the data products would be useful when available on an operational basis.

The individual ranch product test is presently underway with the help of TAEX. Data products to be furnished these ranches are green vegetation amount and distribution within and between management units periodically throughout the growing season.

Satellite based resource information is useful to two different user classes in the State of Texas. It has been successfully tested by both the technical and lay communities.

This project outlined an interactive method of evaluating new data for the resource manager. Not all remote sensing products are useful to each manager, therefore, his needs and wants must be met and incorporated into the process. With only minor local modification, this interactive approach is applicable anywhere in the world.

The present project is the first "near real time" test of operational remote sensing data for resource managers.

Key words: remote sensing, resource management.

13-1-5 Optimizing the Use of Grazed Dryland Pasture in Western Oregon

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When properly fertilized, western Oregon dryland pastures of subterranean clover with grasses such as perennial ryegrass, tall fescue, and resident annuals produce total annual dry matter yields averaging 6500 kg/ha. Some sites are capable of over 9000 kg/ha. Optimum use of this forage is complicated by its highly seasonal availability. Over 50% of the total growth occurs from late April to mid-June. Only about 10% takes place during autumn-early winter and virtually none occurs during summer. Research shows livestock weight gains from 300 to over 700 kg/ha can be expected depending upon pasture mixture and kind of grazing use. Yearling cattle make the most efficient use of rapid spring growth. As grazing season lengthens, total animal production declines both because nutritive value declines and old forage must be present for use during the summer dry and fall-winter wet periods.

Four major livestock production programs exist: (1) sheep (winter lambing), (2) beef cows calved in autumn, (3) cows calved in spring, and (4) purchased calves/yearlings. Hay cut from excess spring growth is usually fed during winter except in some coastal situations where appreciable winter plant growth occurs.

By utilizing known characteristics of forage production and animal requirements, forage demand curves were developed. Yearlings stocked at 6-7.5/ha from mid-March to late June make highest weight gains per unit area as compared to cows/calves and ewes/lambs. Animal performance of about 100 kg/head or 730 kg/ha is possible on subclover-tall fescue in the Willamette Valley. Shorter duration of adequate forage quality with clover-ryegrass yields about 560 kg/ha. Pastures are capable of sustaining 10 ewes/ha but few operators stock that heavily. Production of lamb per hectare on clover-ryegrass pastures can be similar to that by yearling steers; but on clover-tall fescue or clover and other coarse grass, it will be less. Sheep do not consume coarse grasses such as tall fescue as well as cattle.

Calf production from cows calved in spring is the modal form of beef operation. But, autumn-born calves and their dams make more use of spring forage than spring cow-calf pairs. From 27 to 45 kg more weaning weight can be expected. Wintering costs for this autumn cow-calf pair are an estimated $10-35/head more. From a comprehensive management standpoint, ewes and lambs with either some purchased yearling cattle or autumn-calved cows appear to yield the most product from dryland clover/grass pastures.

Key words: grazing, dryland pasture, Oregon.

13-2-1

Pasture Demonstrations for Beef: Agronomic Considerations

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Beef cattle supply a major portion of the income for northern Minnesota, but the major resource supporting this enterprise, forage, was vastly under utilized. A five-year on-the-farm demonstration was conducted by the Agricultural Extension Service, University of Minnesota and the Upper Great Lake Regional Commission to improve income in northern Minnesota by improving operations of the beef enterprise.

We compared one or two improved pasture systems to an unimproved permanent grass pasture comprised predominantly of Kentucky bluegrass (Poa pratensis L.), "system A," on each of six ranches. Improved systems included use of a cool-season grass fertilized with 138 kg N/ha for spring and fall grazing and either birdsfoot trefoil (Lotus corniculatus L.) or a legume-grass mixture [alfalfa, (Medicago sativa L.), red clover (Trifolium pratensis L.), smooth bromegrass (Bromus inermis Leyss.) and orchardgrass (Dactylis glomerata L.)] for summer grazing. Both grass and improved legume or legume-grass pastures were rotationally grazed, and excess forage was harvested for hay. "System B" involved use of 6 ha of birdsfoot trefoil and 8 ha of fertilized grass. "System C" contained 9.6 ha of legume-grass and 6.0 ha of fertilized grass. A fourth system, "AA," had Kentucky bluegrass fertilized once a year with 55 kg N/ha. All pasture systems carried 25 to 30 animal units (AU) and we used cows and calves, except in one case, lightweight yearlings, to measure productivity.

The introduced cool-season grass species, smooth bromegrass, yielded more AUM/ha than did the native Kentucky bluegrass when both received the same amount of N fertilizer. Legumes provided pasture during 70 to 90 days of the grazing seasons (100 to 132 days). Harvesting of excess forage improved its utilization, but if the excess was not harvested early, sufficient fall pasture was limited.

Animal liveweight gains/ha increased from the use of improved pasture management systems on all six ranches. Gain increases ranged from 182 to 480% from the best system compared to system A. When extra harvested forage was converted to extra calf gain, at least two ranches produced more calf gain/ha (96 to 236 kg) than shown at an agricultural experiment station.

Key words: Kentucky bluegrass (Poa pratensis L.), smooth bromegrass (Bromus inermis Leyss.), orchardgrass (Dactylis glomerata L.), alfalfa (Medicago sativa L.), red clover (Trifolium pratense L.), birdsfoot trefoil (Lotus corniculatus L.), cow-calf, yearlings and pasture systems.

13-2-2

Grassland Societies in Manitoba

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Manitoba Agriculture

The purpose was to improve, by demonstration, the traditional management practices used by livestock producers for pastures and forage production for beef and dairy cattle herds. Cooperating farmers were organized into Grassland Societies, which enlisted the support of specialized persons supplied by Manitoba Agriculture. Results over five years were clearly positive, and significant improvements were noted in both field and animal husbandry practices. The experience confirmed the principles of the diffusion-adoption process and its application to adult extension education.

Key words: information diffusion and adoption, beef and dairy producers.

13-2-3 An Interaction Pasture/Cattle Production System Simulation Model

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Climate favors pasture production in the southeastern United States so that cattle can be raised year-round on forages. Carrying stocker steers to heavier weights on cool-season forages is becoming a profitable enterprise in the region. A computer simulation model which accurately reflects performance of this pasture/cattle production system offers the possibility for comparing economic benefits of alternative management strategies.

A FORTRAN-based model was developed and verified for a tall fescue (Festuca arundinacea Schreb. cv Kentucky 31) pasture using historical weather data for central Alabama. The forage portion of the integrated model was based on a model by Smith and Williams (J. Range Mgt. 26, 1973), and the cattle portion by Sanders and Cartwright (Agric. Systems 4, 1979). Response surfaces representing forage growth to variations in solar radiation, temperature, and soil fertility were generated by regression analysis of small plot data. Daily observations of mean air temperature, rainfall, pan evaporation, and solar radiation were driving variables influencing forage growth, drying, and decay. Available standing biomass, crude protein, and digestible dry matter were estimated each day for the forage. Output variables from the forage portion of the model were inputs for the cattle portion of the model. Parameters in the livestock section were initialized for stocking rate and genetic potential of the animals. Stocking rate influenced the rate of forage removal by the cattle, and the genetic weight of the dam determined the shape of the animal's growth curve used for model predictions. Grazing pressure represented a feedback mechanism affecting forage growth and quality in the next daily time step.

Model predications indicated that the forage/cattle model tracked observations for six separate experimental periods from 1975 to 1978 for sets of steers grazing fescue. The level of maximum standing biomass varied between fall and spring periods. In the fall periods with cattle grazing, maximum standing biomass reached 1161 kg/ha, while for spring periods standing biomass was greater, averaging 3458 kg/ha. Pasture fertilization rates were 300 kg/ha. In only one of the experimental periods was the pasture stocked too heavy to support the set of steers for the entire grazing period, resulting in decreasing rates of daily weight gain.

For an estimated dam's weight of 480 kg, the model predicted animal's measured weights for the six periods on the average within ± 10 kg/animal. The widest deviation between predicted and measured was -21.45 kg/animal, and the closest was + .37 kg/animal. The sensitivity of the model to variations in forage and cattle parameters indicated that certain parameters have more influence on model's predicting capabilities. The model demonstrated the capability to estimate benefits for alternative animal sizes and fertilization rates for a pasture/cattle system in Alabama.

Key words: Alabama, fescue, steers, stocking rate, economics.

13-2-4 The Adoption of Leucaena for Cattle Grazing in Australia

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The tree legume Leucaena leucocephala is a high quality cattle forage in many tropical countries. For the past thirty years, cattlemen have not planted leucaena despite conclusive evidence from small grazing experiments that it improved beef production and is suited to a large area of northern Australia. Seed of four cultivars was available in the 1960s. In 1968 cultivar Peru, an excellent forage type, was planted in a 24-ha block specifically for seed production. But little of this seed was used in Australia. There were several likely reasons for the non-adoption of leucaena. Adverse publicity on the extreme effects of mimosine toxicity, limited ecological adaptation and problems with establishment created barriers to adoption. Most important, rotational grazing in short cycles advocated for leucaena hedgerows by researchers was in direct conflict with traditional continuous grazing management of native and improved pastures. Extension officers lacked confidence in leucaena and refrained from recommending it.

A management system, where leucaena maintained a canopy permanently out of reach of cattle, allowed continuous grazing of accessible forage without detrimental effects on the leucaena plants and cattle feeding on them. Since 1974 this management system has been effectively used by the producer with the 24-ha Peru cultivar. In November 1979 a promotional program on leucaena for cattle forage commenced in central Queensland. There was an immediate response from cattle producers. In 18 months 450 ha were planted and the area could be expected to increase rapidly in the next few years.

There may be several reasons for the recent commercial acceptance of leucaena. It was concluded that the main reasons were that the positive promotional program clearly defined the role and adaptation of leucaena, and emphasized that its management could be simple and not in conflict with traditional practices; establishment was inexpensive and uncomplicated and that the inaccessible canopy ensured longevity, reliable seed production and was a valuable drought reserve. Fears on undesirable features were dispelled. The 24-ha commercial block instilled further confidence in leucaena.

The reasons for adoption of leucaena in Australia may be of benefit to other countries experiencing adoption problems. The transfer of grassland research findings to ranch practice is nearly always beset with difficulties. This is more pronounced in extensive ranches with traditional practices entrenched. Research and subsequent promotion of a new ranch innovation should recognise features which lead to rapid adoption, important ones being its benefits, simplicity, compatibility with existing management and being observable on a commercial scale. For new crops, seed must be readily available when promoted.

Key words: leucaena, Leucaena leucocephala, grazing, cattle, extension, adoption.

13-3-1 Sward Height: An Index of Grazing Severity to Aid in the Management of Pastures for Cattle

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The herbage intake of the grazing animal determines its production. A major factor controlling the level of intake is the severity of grazing imposed by the grazier. This work was undertaken to define relationships between grazing severity and both herbage intake and animal production, from which objective guidelines for the management of rotational and continuous systems of grazing could be developed. Trials on perennial ryegrass (Lolium perenne) swards have included work with spring-calving dairy cows, suckled cows and their calves and beef cattle.

Sward height, which can be easily measured with a ruler, has been used as the simple index of grazing severity, after grazing in rotational systems or throughout grazing in continuous systems.

It has been found that once cows are forced to graze the sward below a height of 8-10 cm in rotational systems herbage intake is increasingly depressed; milk production is similarly depressed. However, these reductions are dependent upon the duration and severity of restriction since the cow is, to a limited extent, able to buffer short-term intake limitations by drawing on body reserves. The relatively lax severity of grazing necessary for individual animal intake and milk output to be maximized results in inefficient utilization of the total herbage grown and an output of milk per unit area well below maximum. For milk production per ha to be maximized an increased grazing severity must be applied and a reduction in individual animal performance of up to 20% accepted. With continuous grazing significant depressions in herbage intake occur with cows grazing swards of less than 6-7 cm in height. Again the reductions in milk production depended on the duration and severity of restriction.

The major difference between grazing systems has been in the contrasting growth habits of the swards produced. We have not found differences in either the amount of herbage grown or utilized. However, there have been marked differences between the two systems in tiller populations and in their seasonal changes.

The choice of grazing system has not been important in determining output in our trials on heavily fertilized swards but the major influence has been the way in which the system is managed to match grass supply with animal requirements. We have shown that it is possible to assess the effects of grazing severity on herbage intake from a simple measurement of sward height. This can give an early warning of the likely effect on milk production. It has also been found that similar guidelines can be applied to grazing beef cattle and suckled cows and their calves.

Key words : grazing, management, cattle, sward height.

13-3-2 Dry Matter Yield of Alfalfa Under Various Environmental Conditions in the Tokachi Region

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In spite of the importance of alfalfa for all kinds of livestock, particularly for dairy cattle, the cultivation of alfalfa has not yet expanded in the Tokachi region of Hokkaido, Japan. A comprehensive research project has been undertaken, based on observations of long-term effects of chemical fertilization on the maintenance on longevity and obtaining of a high productivity of the mixture of alfalfa and orchardgrass. This report is concerned with (1) the dry matter production of alfalfa and orchardgrass, cultivars of which were introduced from the U.S.A., and (2) the ratio of alfalfa to orchardgrass and uptake of N, P, K, Ca and Mg. The research began in 1960 and is on-going in close communication among co-researchers in Japan, the U.S.A., and the Federal Republic of Germany. This project calls for introduction of technical equipment as well, for example, band seeder. The experimental results are summarized as follows:

1. Phosphorus applied as a basic fertilizer was very important for the growth of forages, particularly in the seedling stage.
2. Alfalfa topdressed with K produced a higher dry matter yield and maintained a higher percentage of alfalfa in the sward, as compared to absence of K fertilization.
3. Percentage P in forages decreased gradually and came to indicate a critical value after 10 years. As the result of application of P, however, the dry matter yield increased and percentage P recovered to the normal level. The application of P and K was necessary for both the normal growth of forages and the production of a high dry matter yield.
4. Application of P and K enhanced stand longevity of alfalfa during 20 years.
5. Application of P and K stimulated the activity of nitrogen-fixing bacteria and increased percentage N in forages.

Key words: alfalfa (Medicago sativa, L.), orchardgrass (Masshardy), longevity, dry matter yield, phosphorus application, potassium topdressing

13-3-3 Vegetative Response to Grazing Systems Management in Wyoming's Red Desert

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Over the past 60 years livestock grazing systems have been studied to aid development of range management techniques that will provide higher sustained forage yields of native perennial grasses. On many rangelands rest-rotation and deferred systems have proven superior to continuous grazing for management purposes, while on others this has not been true. The objective of this particular study was to determine the influences of different grazing systems on arid shrub-steppe vegetation of Wyoming.

The study site was located on the Red Desert in south-central Wyoming. In 1966 three grazing units were designated: a four-pasture rest-rotation unit, a two-pasture deferred unit, and a continuous seasonal-use area. Cattle stocking rates were adjusted to reduce grazing pressure on a depleted range, and to equalize forage use over the three units. Vegetation cover and utilization were measured on 43 permanent cluster transects located in sagebrush-grass types on the various pastures. The transects, consisting of twenty 30cm x 30cm quadrats each, were randomly placed within areas of moderate grazing intensity. Vegetation cover data was recorded in 1967, 1971, 1975 and 1979, while utilization data was collected annually from 1967-1971.

Changes in vegetation cover between 1967 and 1979 expressed an upward trend in range condition on all three grazing units. Perennial decreaser grasses such as Indian ricegrass (Oryzopsis hymenoides) and needleandthread (Stipa comata) made significant gains ($\alpha = .05$), while big sagebrush (Artemisia tridentata) and plains pricklypear (Opuntia polyacantha), both invaders, either declined or remained unchanged. Perennial increaser grasses such as western wheatgrass (Agropyron smithii) and Sandberg bluegrass (Poa secunda) made gains on most pasture units. Changes in amounts of cover for decreasers, increasers, and invaders were compared among the three units. All changes were equivalent, indicating that upward trend of range condition has been occurring at a uniform rate on all units. Utilization of desirable perennial grasses ranged from 27-57%, with approximately equal use among pastures on individual species.

Because decreaser plants exhibited cover gains and invaders declined, it is apparent that range condition has been improving. Gains by increaser plants indicate range improvement has not yet progressed to the stage where their populations stabilize prior to the decline associated with trend movement toward the excellent condition class. Utilization data substantiates the original premise of equal grazing pressure on all sampling sites, and reveals that intensity was in the light-to-moderate range. A rainfall-related bias can be eliminated because long-term precipitation over the area was relatively uniform. This study shows that, after 13 years, continuous grazing was as effective in range management as deferred and rest-rotation grazing, under the following conditions: (1) the range type was northern arid shrub-steppe; (2) the condition class was in the lower range of condition classification; and (3) the stocking rate was light to moderate.

Key Words: grazing systems, arid lands, range condition, range trend.

13-3-4 Alternative Forage Production Patterns for Dairy Cattle Under Conditions of Limited Water Supply in Northern Mexico

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In the desert climate of northern Mexico groundwater resources are being exploited in forage production for the dairy industry. As rest water levels are currently falling by 1.75 m annually, there is an urgent need to examine the water management efficiency (WEI) of present forage cropping patterns, and replace the leff efficiently managed species without decreasing the overall regional mean milk production of 14 liters/cow/d. The present study describes the approach taken to achieve this, and the implications for increased water management efficiency in this region.

Data are drawn from (1) on-farm surveys of 6[illegible] forage and 26 dairy production units; (2) on-station feeding trials; and (3) small plot studies. The principal analysis is the efficiency of transformation of water into forage DM and milk.

Annual forages (corn, sudangrass, Italian ryegrass, oats) were compared individually with alfalfa in sole forage diets for milk production. Although milk yields were lower with the alternative forages, WEI to milk and feed costs per kg milk produced were improved in every case. Milk production/cow did not decrease below the regional mean.

The present regional cropping pattern (1978) produces 1.6 million t of green forage with an approximate WEI of 0.38 kg DM m^{-3} H_2O. By replacing alfalfa (67% cropped area) with larger proportions of annual forage, WEI could be increased by 12%, while reducing water input by 19%. Greater uniformity of water requirement across the year makes a pattern based on annual forages more attractive in a region where mean well extraction rates are 35 liters/s.

Regional basin irrigation technology is considered to be the greatest constraint to water use efficiency. A 25% decrease in water depth per application (officially estimated at 0.16-20 ha m) would increase WEI by 49% to 1.24 and decrease groundwater exploitation by 39%. As measurement determined by 0.22ha m to be the realistic value, the potential saving is even greater. It is concluded that only savings of the latter magnitude will have a significant impact on the future prosperity of the region.

Key words: water, forage patterns, milk production, alfalfa, Italian ryegrass, annual forages, irrigation technology.

13-4-1 Legume Renovation of Grass-Dominant Swards: A Data-Based Educational Program Which Resulted in Practice Adoption by Kentucky Farmers

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Kentucky has about 2.83 million hectares of forage crops, most of which are located on land with moderate to severe erosion hazards. By the early 1950's, one cultivar (Kentucky-31) of tall fescue (Festuca arundinacea, Schreb.) had been planted on a proportionately large area. Legumes grown with grasses had been shown to greatly improve quality of forage.

Legumes were lost from many Kentucky grass fields during the relatively dry summers of 1953 and 1954. Legume establishment research was expanded at the University of Kentucky in 1955. By 1959 sufficient data had been accumulated to formulate recommendations and begin educational programs for farmers.

Counties to receive intensive educational program emphasis were selected in 1959 and in each year thereafter through 1965. County agents, county leaders, and the extension forage specialists met in each county and concluded that pasture production and quality were the major livestock problems which needed attention.

Numerous demonstration plantings were made at easily accessible and highly visible locations in each of the participating counties. Information campaigns were conducted in the selected counties through radio, television, newspapers, farm magazines, and direct mail to create an awareness of: (1) the need for legumes in grass fields; (2) the fact that legumes could be established without plowing; (3) locations of renovation demonstrations, and (4) where additional information could be obtained. Educational activities included county and neighborhood classes, field days, and tours.

Estimated hectares renovated statewide increased from about 7,000 ha. in 1960 to 243,000 ha. in 1967. The number of total cattle and calves in one of the early high educational emphasis counties was increasing during the 1949-69 period at about the same rate as the district in which it is located. From 1969-75 the high emphasis county increased at a rate much faster than the district. A comparison between eight selected high emphasis (HE) and eight low emphasis (LE) counties shows the HE counties to have increased cattle numbers more slowly than the LE counties during the pre-program period, 1949-59. After 1959 the HE counties increased cattle numbers faster than LE counties. Although no cause-effect relationships between renovation and increased cattle numbers can be proven, it is probable that there was an effect as a result of increased feed production.

Prior to 1960, "renovation" was a word never used with reference to a grass field. In 1980 a survey was conducted in 30 randomly selected Kentucky counties. Of those livestock farmers responding to survey questions, 72% said that renovation is a common practice on their farms and 73% said extension had either "much" or "very much" influence on their decision to renovate. Thus it would appear that extension education programs have been influential in the renovation of grass fields becoming a routine practice on about 3/4 of Kentucky's livestock farms.

Key words: renovation, legumes, extension education, practice adoption.

13-4-2 Rise and Fall and Rise of the Moroccan Range Science Empire

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By following the case history of the establishment of range management as a science in Morocco, this paper evaluates the impact of assistance efforts. The paper then weighs the merits of the various projects, asking what initial setbacks are unavoidable and how can we better coordinate and conduct these assistance efforts.

The Ministry of Agriculture of Morocco and the U.S. Agency for International Development (USAID), in 1966, recognized the magnitude of the rangeland problems in Morocco. However, the lack of qualified Moroccan range management personnel, the failure to identify appropriate technology, the inability of available specialists to involve pastoralists in decision-making on range perimeters, and a lack of knowledge of herders' social structure and pastoral traditions made it impossible to demonstrate the expected benefits of the resulting project to the pastoralists. The United Nations Food and Agricultural Organization (FAO) also conducted a management/extension effort, but once again the project failed to accomplish its goals because of a lack of trained manpower. Both of the above projects, however, did introduce the concepts of range science to the country and provided physical facilities and legal procedures for future action.

Beginning in 1968, a period of educational type projects began, the first of these a 5-year FAO Project which trained one Moroccan. The first participants under a USAID/University of Minnesota Project returned to Morocco in 1974 with a Moroccan Third Cycle Degree. Since that time a total of 15 range scientists have taken course work at nine different U.S. universities. In addition, five Ph.D. students are studying at five different U.S. institutions. Adding to the pool of trained range scientists, the USAID Title XII Small Ruminants Collaborative Research Program and a USAID Dryland Farming Project began in 1980.

Building on the interest generated in rangelands over the last 14 years, the World Bank (IBRD) began a community development effort in 1981. The Moroccan Ministry of Agriculture is now convinced that the time is right for another extension effort. At this time cultural characteristics of Moroccan pastoralists appear adaptable to a change away from traditional animal numbers/wealth and status equations.

Range Science is gaining a firm foothold in Morocco after 14 years of assault. The questions that are addressed in this paper, with relevance to future activities, are: Can this course be shortened? Are what we view as initial failures really failures or are they necessary steps in demonstrating the needs? Is it possible to coordinate the activities of all world organizations within a subject matter within a country or must we continue to repeat mistakes? Should foreign aid be involved in non-educational type efforts or should this be the responsibility of the host government? Can we modify the training we are providing to be more socially sensitive? At what level should our training be directed? Can we ever provide effective extension training or must this phase be developed and conducted by host government personnel?

Key words: Morocco, range science, education, USAID, research, extension, demonstration.

13-4-3 West Virginia University Allegheny Highlands Project: A Ten-Year Experiment in Technology Transfer

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West Virginia's livestock industry is characterized by relatively small units located predominantly on rough terrain suited to neither highly mechanized nor intensive agriculture. As a result of changes in agriculture during the last 40 years, there has been a reduction in support from agribusiness, in marketing alternatives, and in profitability. Some contend that, if present technology were adopted, beef and sheep farms in mountainous regions would be profitable and would collectively contribute to the local economy.

The objective of the Allegheny Highlands Project was to test the effectiveness of a method of delivering technological information to farmers as a means of promoting rural development. A multidisciplinary team composed of specialists in agronomy, animal science, farm management, and veterinary medicine worked together to provide to producers a package of recommendations designed to increase production and/or profitability of their farm operations.

Comprehensive production, inventory, and financial data were collected on 65 farms from 1971 through 1979. Linear regression analyses were used to assess the importance of number of years of project participation, year of entry into the project, farm size, farm enterprise, method of technology transfer, and time devoted to farm operation on changes occurring in farm production, inventory, and income. Years of participation in the project had a significant influence on hay yields/ha, 205-day weights of calves, market weights of calves, value of calf per cow, lambing percentage, marketable lamb crop percentage, weight of lambs when sold, kg of lamb marketed per ewe, and value of marketable lambs per ewe, all of which increased. Large farms without nonfarm income had higher hay yields/ha than other farms. The 205-day weights and market weights of calves were less on farms managed by part-time farmers who placed minor emphasis on farming. Large farms had more liabilities, receipts, expenses, and net income than smaller farms. Most production goals established on a farm basis were achieved, whereas production goals for the Project area were not achieved.

The package approach used in the Allegheny Highlands Project was successful. Farmers benefitted from increased production and increased income. Farmers and community attitudes became more positive and cooperation increased. The University benefitted from increased contacts with clientele, which resulted in more meaningful research and teaching. Elements found necessary for a successful project were: goals and procedures, competent staff, appropriate disciplines to meet farmer needs, mutual confidence between farmer and field staff, community involvement, adequate funds, administrative support, continuity of staff, and adequate time. The authors concluded much of the present technology is applicable but needs modification to meet individual needs, one-to-one contacts are the most effective means of getting technology adopted, people farm for different reasons, and, in general, changes occur slowly.

Key words: package approach, small farms, technology transfer, Allegheny Highlands, rural development.

13-4-4 Suppositions and Importance of Pasturing of Cattle in the German Democratic Republic

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The pasturing of dairy cows and heifers is characterized not only by a comparatively small expense of machines and tools, workers, and costs, but also by a high adaptability to plant yield, concentration of animals, intensity of production, and economical conditions. This adaptability is important for the German Democratic Republic (GDR), because the named factors exhibit a considerable diversity even within this limited area.

The 530,000 ha of pastures in the GDR occupy about 25 percent of the main forage area for cattle and sheep. The politico-economic pressure to obtain high yields, forage utilization without losses, and high performance per animal applies also for these pastures. Per inhabitant we have at hand only 0.37 ha, but the a head-consumption of animal products is very high: more than 89 kg of meat, 15 kg of butter, 7 kg of cheese, and 100 kg of drinking-milk.

Dairy cows are kept in houses with 15 to more than 4,000 places; heifers are raised in houses with 18,000 or less than 50 places. The size of the grassland areas to be grazed and also the size of the pasture areas belonging to an enterprise of plant production vary between only a few to more than 1,000 ha.

The organization of pasture management is adapted to the very different conditions. In regions with connected large grassland areas pasture combines with two herds, each of 200 to 300 dairy cows or 400 to 600 young cattle, have proved a success. Small dispersed pasture areas are used mostly with herds of only 40 young cattle or about 20 to 50 cows direct from the shed, if the pastures are close to the village. Where the grassland areas are situated far away from the shed, stationary pasture centers for dairy cows have to be erected. In these combines two herds of 200 to 300 dairy cows each are cared for efficiently (ca. 1 labor hour per dt of milk). Also dairy cows, which in winter have to be kept in old sheds hard to mechanize, are gathered on pasture in two herds of 200 to 300 animals each. There are not a few cases in which this way during the pasture period 500 cows are cared for by 3 shift-collectives of 4 members each of an agricultural cooperative. One shift-collective works in morning shift (7 days), the other in late shift (7 days), the third has free time (varying 3 and 4 days). Whereas for 500 cows 24 workers are needed in winter, only 12 are necessary in the pasture period. In this way it is possible that the workers in cattle production can take their holidays in summer and that measures of rationalization on the sheds can be performed.

Key words: pasturing, cattle, GDR, organization, productivity.

12-5-1 Effectiveness of International Students as Professionals in Their Home Countries

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The observations made in this paper are based upon contacts with international students, both in the United States and in many countries of the world. The author has supplemented observations over a 30-year period in higher education with interviews and contacts during a three-month intensive study period in the Sahelian-Sudanian Zone of Africa.

Two of the most serious problems in increasing world food production in the developing world are: (a) lack of trained people, and (b) technology transfer. A third constraint, inadequate research, is also critical but not of the magnitude of the other two, since there is a great amount of research information available that is not being adequately utilized.

Training needs fall into two general categories where deficiencies are obvious: (a) graduate level programs, particularly in the applied fields relating to range ecology and grassland management, and (b) "technician" level training, which may be below the B.S. equivalent level.

Most international students, after their return to their home countries, expressed enthusiasm about their training in the U.S. They were less enthusiastic about training in other countries because it was "more basic" and "not as practical" or useful for their jobs at home. Also, there appeared to be more effective training at institutions within "similar ecologic zones" whereas training--particularly in the agricultural sciences--in "dissimilar" zones was not as effective for their purposes. Careful selection of universities abroad is very important.

There was almost a unanimous feeling among foreign-trained students, as well as agencies involved in development assistance, that the research required for a Ph.D. be conducted in the country of the student's origin. This requirement may not be as critical if the research is more applied than basic and if the research is carried out in similar ecological environments. Even though "in-country research" poses some managerial and financial problems to foreign universities, this point cannot be over-emphasized.

While most of the Less-Developed Countries require some service (usually 5 years) in the home country after the degree is conferred abroad, there is evidence of substantial out-migration of trained personnel in many of these LDC's. As one professional in an LDC stated, "We are training our people for jobs in Saudi Arabia where the salaries are much higher than we can afford."

The working environment in many LDC's is depressing for the returning professional. Some cannot get foreign exchange to maintain their professional ties to such organizations as the Animal Science Society, the Agronomy Society or the Society for Range Management. Some find it virtually impossible to communicate with other professionals in their field, no library, and no intellectual stimulation. It is indeed unfortunate to observe the trained mind in an environment that will not permit growth and development.

Key words: international, professionals, training, technology, transfer.

13-5-2

Innovations in Academic Curricula for International Education

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A major contribution USAID has made to developing countries has been to support the education of host country nationals. This form of assistance has not been without its problems, as both AID and the universities themselves have been less than totally effective in meeting the challenge of providing an education that best serves the student and the home country.

In most developing countries the BS degree serves as adequate scientific foundation for staffing agricultural programs. This is not to argue against higher levels of education but to state faster progress can be made by spreading the educational efforts among more individuals at a training level better suited to the needs of the country. There is evidence that U.S. institutions have been guilty of prolonging the educational experience of third-world personnel beyond the need.

When students from lesser developed countries pursue graduate degrees, the U.S. institutions providing the education and the organization sponsoring the student should find a way for the required thesis or dissertation research to be done in the home country.

At the BS level foreign nationals being educated in U.S. universities should not be subjected solely to curricula developed for U.S. students and U.S. conditions as is now the predominant case. It is necessary to relate the U.S. technology, principles, and concepts of agriculture and natural resource management to the cultural and political realities of the LDC. This means special courses must be developed to do this and U.S. faculty must have the experience and willingness to properly develop and teach those courses.

This paper proposes some possibilities for undergraduate and graduate curricula in the U.S. to furnish more meaningful education for international students.

Key words: international education, academic curricula, education.

13-5-3 Role and Effectiveness of U.S. Universities in Training Professionals for Work in International Agriculture

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Problems of hunger, malnutrition and world food security became a major world concern in the 1970's. Two U.S. Presidential reports have emphasized the seriousness of the situation and the need to expand food production and distribution, particularly in the less-developed countries (LDCs) where hunger is most severe.

The LDCs need to strengthen agricultural teaching, research, and extension in order to develop and disseminate the appropriate technology farmers need to increase food production. The most limiting factor is often the lack of trained scientists to provide the local leadership and expertise. Here the U.S. and other developed country universities are needed to train LDC professionals as well as provide technical assistance overseas.

U.S. universities have been encouraged to expand their international activities through Title XII legislation passed in 1975. While the Act has not been fully funded or implemented, it has been a major step toward the long term support U.S. universities need to seriously take on the job of international agriculture. Demand for U.S. training from LDC students and the need for U.S. expertise overseas has continued to increase during the 1970's while support for U.S. university-based work has substantially declined. Younger U.S. professionals in particular seem to be deserting their interests in development.

These circumstances led the American Agricultural Economics Association (AAEA) to sponsor a major study on the training of foreign students in U.S. universities. Principal objectives were to obtain an evaluation from LDC alumni on the strengths and weaknesses of their U.S. training; determine what the U.S. can do to assist in strengthening indigenous training and research capabilities in the LDCs; and assess the future capacity of U.S. universities to meet LDC research and training needs.

Results indicate that LDC agricultural economists value their U.S. training highly; it has given them the confidence, analytical tools, and problem solving skills they need to work in their own countries. They would like greater application of economic tools to their own situations. More U.S. professors need real knowledge and experience in developing countries and students should be able to do their thesis research on a home country problem. It is also important to maintain collaboration with their U.S. professors and departments after returning home. Cooperative research, short courses and seminars, and post-doctoral programs were suggested as means for continuing support.

Over 40 percent of young U.S. agricultural economists have deserted their interests in development. U.S international capabilities in this discipline appear to be declining. Probably the most critical factor is the instability and low level of funding for university participation in international development activities. Increasingly stringent university budgets and little public support for assistance to LDCs have made it extremely difficult for U.S. universities to recruit and maintain faculty in international development.

Key words: international training, U.S. universities, world food supplies, agricultural development, technology, hunger and malnutrition.

13-5-4 Techniques for Improving Our Technology Transfer

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Students from the developing countries who are studying one of the natural sciences or branches of technology in a U.S. university are exposed to the same curriculum as their U.S. counterparts. The content of this curriculum is dictated by the kind of tasks a graduate is expected to do in the U.S. environment once he or she gets a job.

Both personal observation and research experience of the author suggest that in the developing countries the environment into which the young scientist finds himself or herself immersed upon return from graduate studies in the U.S. is quite different from the U.S. one. In such an environment, the young scientist finds himself or herself using most of his/her time in trying to create the necessary conditions to begin effective work, and ends up failing because his eventual collaborators lack the necessary abilities to complement his/her skills. Worse, he cannot teach them these abilities because he, himself, has never acquired them. No one bothered to teach him these abilities in the U.S. because they were not part of the job of a scientist or technologist as seen in those societies. The frequent outcome of this situation is the emigration of the young scientists to the scientifically advanced country where he was trained, because there he will be able finally to do research.

It seems, therefore, that the education of scientists and technologists coming from the developing countries should not be identical to that offered to the U.S. citizen, but should consider the different sociopolitical environment of scientific research in the former countries.

If it is accepted that this kind of education is indispensable for science and technology students from the developing countries if the major investment in their training is to bear fruit, how is this notion to be implemented in a U.S. university? It is out of the question to modify the curriculum of science or technology education in individual inst tutions of higher education, which must bear in mind basically the environment of their own societies. But such an education could be provided if one were to combine the normal curriculum of the departments in these universities with a complementary curriculum that would be offered only to students coming from the developing countries.

Key words: techniques, technology transfer, developing countries, students.

14-1-1

Income, Costs, and Profits Associated with Feeding Selected Forages to Dairy Cows

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Over the past 10 years, dairy farm enterprises have grown in size with an apparent increase in the use of scientific feeding and management techniques. There is growing emphasis on automated feeding and milking and management strategies in an attempt to reduce labor needs and allow more cows per worker. It is apparent from data collected in this study that herd growth, use of automation, and a scientific management approach will continue. The average herd size from the sample population was 76.8 cows. There was difficulty finding over 100 and under 40 head herd sizes. It appears the trend in increasing growth will continue as sufficient capital, management ability, and debt service capacity exist to allow the growth to occur.

Forage management also has changed over the past 10 years with more emphasis on alfalfa (Medicago sativa L.) as a means of reducing purchased protein needs and controlling feed costs. This change has led to increased use of soil testing, forage testing and forage fertilization by Wisconsin Dairymen. Low moisture silage (LMS) as a means of reducing labor and preserving forage quality has increased and has resulted in growing dairy farm investments. Producers relate LMS forage systems to the use of high quality feed, reduced feed costs, and automated feeding.

Current forage trends will continue to decrease the importance of corn silage and dry hay on dairy farms as younger operators move into the dairy industry and engineering results in new developments to benefit forage harvest and handling systems.

A result of such trends is increased capital need, as has been witnessed in the recent past and will be more critical in the next several years. Machinery, storage, and handling facilities are major factors dictating present-day investment needs and have resulted in the producer's need to increase cow numbers to offset the overhead costs and generate sufficient profit margins.

Objectives of the study were to: 1) gather and analyze relevant production and economic data; 2) determine the interrelationships between production and economics; 3) identify the effects that identified changes have had on production and economics; 4) determine how forage systems and herd size are related; 5) determine if there are economies to scale in size of operation; and 6) identify what dairy farmers are currently experiencing.

Key words: dairy trends, herd size, forage systems, management methods, economic relations.

14-1-2 Socio-Economic Limitations to Extensive Forage-Livestock Production Systems

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Cheap prices for energy and fertilizer and the relatively favorable climate of the 1950s and 1960s contributed to the habitual expectation of surplus grain production, low prices, large reserves, and consequent abundance of grain for livestock feed. Grain feeding of livestock increased in many developed countries and it was frequently suggested that intensive grain-oriented livestock production systems might be a key to improving productivity in less-developed countries. This situation changed dramatically in the early 1970s. There were substantial shortfalls in world grain production in 1972 and 1974. At about the same time there were phenomenal increases in energy and fertilizer costs. Between 1972 and 1974, petroleum prices increased by more than 500% and bagged urea and phosphate, for example, increased in cost by more than 675% and 700%, respectively. Grain has not been a primary source of livestock feed in much of the world in any case. Over 90% of livestock feed on a worldwide basis comes from forages. Yet even where grain has been an important source of livestock feed (e.g., Western Europe and the US), emphasis on it is decreasing. In the US, grain feeding of livestock reached its peak in 1972. It seems virtually certain that energy and fertilizer costs will continue to increase. Consequently, extensive livestock production systems which rely on grassland forage become increasingly important. The ratio of digestible energy output per unit of fossil energy input is as much as 40 times higher for pasture forage than for corn grain feed, for example. There is a continual need to increase food production due to continued rapid growth of world population. There is much talk of the impending world food "crisis." While it is true that pressing food needs result in an emphasis on production of human food crops not livestock (and there is little meat in the diet of many people of the world currently), there are many areas where food crops cannot be grown because of climatic, edaphic, topographic, or other limitations. Many such areas are grasslands, where extensive production of ruminant livestock is the only possible means of using the land for producing food for a hungry world. As the need for food increases, production in these grasslands becomes increasingly important. Yet productivity in these areas is typically very low. There are obvious environmental limitations in lands which are "inadequate" for crop production, but socio-economic factors may be even more important constraints to production. Inadequate marketing structure, transportation systems, and adverse public policy are major obstacles to improving extensive livestock production systems in many grassland areas. Moreover, these obstacles often result in growth of herds, albeit of low quality, beyond the carrying capacity of the range, resulting in environmental degradation which further reduces potential productivity. Such was the case in the Sahelian region of Africa, for example, when a drought between 1968 and 1974 resulted in large mortality of animals and a crisis for the human population of the region. These socio-economic constraints are not limited to less-developed countries, however. In central Australia, such constraints are partly responsible for an increase in cattle to a level five times greater than the number which could be feasibly removed annually with the existing transportation system. Examples from developed and developing countries are offered in this paper to support the contention that socio-economic factors are even more important than environmental factors in limiting productivity of extensive livestock production systems. In some cases the situation may be improved only through a change in public policy.

Key words: world grazinglands, world grain production, livestock production, grain feeding, forage.

14-1-3 Estimation of Digestibility of Legume Forage by Means of Morphological Parameters

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Forage quality usually is evaluated through time-consuming and costly laboratory analyses. Systems would be desirable to estimate forage quality in the field. With single crop forages it seems promising to use morphological parameters for forage quality evaluation. During progressive growth of white clover, red clover and alfalfa the leaf and stem portion was separated to determine the fiber fraction according to Van Soest and digestibility through the procedure of Tilley and Terry. Stem/leaf ratio and stand height to represent stem length were used as morphological parameters.

The leaves of the three legumes show very little variation in the concentration of cell wall material and in digestibility within cuts. The leaf-supporting stems of white clover in spite of increasing cell wall concentration keep up very high digestibility values. As a result for this species no relationship of any practical use turns out between morphology and food quality. In contrast to that in the stem of tall-growing stands of alfalfa and red clover the cell wall concentration increases along with a decrease in digestibility. Significant negative relationships were found between stem length or stand height and digestibility of both alfalfa and red clover, the r-values being 0.95 and 0.80, respectively. These correlations were similar to those obtained between digestibility and fiber fractions according to Van Soest.

In conclusion, it seems possible to estimate the quality of stemmy, tall-growing legumes of known varieties by simple, non-chemical parameters. Since the leaf portion shows very little variation of digestibility it will be sufficient to compute the stem length as related to quality and the corresponding stem/leaf ratio with constant leaf quality to evaluate total food quality. Such a system might be of practical use for farmers.

Key words: white clover, *Trifolium repens* L., red clover, *Trifolium pratense* L., alfalfa, *Medicago x varia Martyn*, growth morphology, digestibility.

14-1-4

Pennsylvania's Alfalfa Growers Program: Four Years of Success

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Alfalfa (Medicago sativa L.) is the most important perennial forage legume grown in the state of Pennsylvania. However, yields currently reported by farmers are considerably below what might be expected when all production inputs are utilized. Therefore, a program was developed to (1) measure how much alfalfa hay, protein, and energy can be produced on a ha of Pennsylvania land under non-irrigated conditions, (2) determine the mineral content and uptake by high-yielding alfalfa crops, and (3) obtain more realistic on-the-farm estimates of alfalfa production costs. To achieve the program goals, hay production for each harvest from 2.02 ha farm fields was estimated using a method developed specifically for this program. Forage samples were taken at the same times and analyzed for quality and mineral content. Cost of production estimates were compiled from enterprise budgets prepared by each grower.

The average estimated yields for each of the four years of the program ranged from 12.3 to 13.0 t/ha (10% moisture) with the highest yield approximately 2½ times the lowest yield each year. The highest estimated production during the four years was hay. 20.4 t/ha; crude protein, 3,898 kg/ha; and total digestible nutrients, 11,648 kg/ha.

Mineral analysis of the forage samples indicated significant farm-to-farm and year-to-year variations in mineral content. Nevertheless for the most part the values were in the normally expected range and virtually no relationship was found between mineral content and yield. Annual mineral uptake also showed considerable variation. For example, P and K uptake ranged from 22 to 72 and from 162 to 624 kg/ha, respectively. The average annual mineral uptake for P, K, Ca, Mg, and S was 41, 355, 147, 25, and 27 kg/ha, respectively.

Average estimated annual production costs compiled for the four years of the program increased from $429 to $656 per ha while the average net return decreased from $401 to $302 per ha. The break-even yield during this period jumped from 6.3 to 8.3 t/ha, approximately 14% per year, emphasizing the need for optimum yields to assure satisfactory returns. The major factors in the annual costs of production were: machinery, 39%,; fertilizer and lime, 20%,; labor, 17%; and land, 17%. Other production costs including seed, spray materials, etc., totaled only 7%.

The Pennsylvania Alfalfa Growers Program has clearly shown the potential for higher production and greater profitability for alfalfa growers in the state through the application of proven production practices and the control of unnecessary production costs.

Key words: Alfalfa Growers Program, measuring yields, quality, mineral uptake, annual production costs, profitability.

14-2-1

Pasture Demonstration Program for Beef: Economic Considerations

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This study makes an economic evaluation of several alternative pasture improvement programs on beef farms in northern Minnesota.

Three questions are addressed relative to several pasture improvement systems. These are (1) will it pay? (2) is there a cheaper way? and (3) is there a more profitable system for a particular farm resource situation? Partial budgeting and computerized linear programming techniques are used to analyze pasture cost and return data obtained from several ranches in northern Minnesota.

Study results show that rented pastures, when available, have provided the cheapest source of additional summer feed; and legume pastures also provide cheaper sources of summer feed than fertilized bluegrass in northern Minnesota. However, if cropland is suitable for growing wheat that will average over 21.5 quintals/hectare or sunflowers that will yield over 1334 kg/hectare, bluegrass pasture should be fertilized so as to release acreage for cash crop production. Also, if hay is not available for purchase, or if hay prices jump significantly over the prices that prevailed in recent years (as they did after droughts of 1976 and 1980), grass fertilization becomes profitable. (At the relatively low hay prices usually prevailing in northwestern Minnesota it is more profitable to buy it and feed supplementary hay during short pasture periods than to fertilize the bluegrass pasture.)

If birdsfoot trefoil can be successfully established it can compete as a pasture crop with alfalfa in northern Minnesota. Using average feeder cattle price relationships, the "best" beef program was consistently a cow-yearling program with heifer feeders sold in the spring and yearling steers sold in the fall. (However, when the feeder price break comes, there usually are a couple years when the cow-calf program is superior.)

In summary it appears that from an economic standpoint pasture renovation is superior to nitrogen fertilization of bluegrass pasture in northern Minnesota. However, pasture land that can be used for cropland might best be converted to other crops and the remaining hectares might then be fertilized in order to carry more beef cattle--at least during this stage of the cattle cycle when returns to the cow herd are likely to be above average.

Key words: Kentucky bluegrass (*Poa pratensis* L.), smooth bromegrass (*Bromus inermis* Leyss.), nitrogen, alfalfa (*Medicago sativa* L.), birdsfoot trefoil (*Lotu corniculatus* L.), beef pasture systems.

14-2-2 Economics of Renovating Mountain Hay Meadows

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There are approximately .5 million hectares (ha) of irrigated native grass hay in the mountain and intermountain regions of California, Oregon, Idaho, Utah, Nevada, Montana, Wyoming and Colorado. Much of these lands are not producing at their full physical or economic potential. There are management activities which land owners may use to increase hay yields on these meadows. The objectives of this study were to identify alternative improvement procedures used to increase hay production and to determine the economic feasibility of those alternatives.

The principal means of identifying alternative mountain hay meadow improvement practices and their costs was personal interviews with ranchers. The ranchers interviewed were owners and/or operators of mountain ranches in Wyoming who were using or had used some meadow improvement practices. Another source of information was previous research on mountain hay meadow improvements and hay production.

The interviews revealed different intensities of hay meadow improvements. These intensities were: 1) farming, 2) farming and structures, 3) farming, structure and leveling and 4) farming and sprinklers. The primary difference between farming and other levels of improvement was the expenditure on capital improvements.

To determine the economic feasibility of these alternative meadow improvement programs, the returns and costs associated with each level of meadow improvement were computed. By deducting the annual production and harvest costs from gross returns the net return per hectare was obtained for each of the intensities of meadow improvement. The annual net returns per hectare ranged from a low of $-140.05 to a high of $167.13.

Using the net return per hectare and the initial capital investment the economic feasibility and relative merit of each level of meadow improvement was determined by discounting the stream of net returns to a common base year. The largest net present value was for the farming option, which was $580 per hectare using a 10 percent discount rate and 20 year time horizon. The lowest net return was for the farming and sprinkler option with a negative $747 per hectare using the same discount rate and time period.

The ranch interviews revealed that farming and structures and farming, structures and leveling were the most common levels of meadow improvement. The economic analysis indicated that these levels of meadow improvements were economically feasible and provide internal rates of return of just over 13 percent up to 28 percent.

Key words: mountain hay meadows, meadow improvements, economics, Western United States.

14-2-3 An Evaluation of the Black Walnut/Tall Fescue Pasture Management System

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The economic and biological feasibility of a tall fescue/black walnut multicropping management regime has been evaluated for comparison with a similar livestock management regime conducted in the open. Research objectives were to evaluate the influence of walnut trees on tall fescue forage production and to determine if the added revenues from black walnut products outweigh the added costs from inclusion of trees in the management system.

Pure tall fescue plots were established under open and black walnut shade conditions. Forage yields on a dry weight basis were estimated for a three-year period. A concurrent grazing trial was conducted on similar sites using 1.2 ha plots. Black walnut seedlings were planted within the plots on a 3 by 12 m spacing and protected from grazing animals by electric fencing. Under the multicropping system, returns would be received over the rotation from the sale of nuts, sawtimber and finally veneer quality wood, in addition to annual livestock receipts. The economic analyses of the alternate grazing systems were based on their respective present net worths and internal rates of return over a 60-year rotation.

The livestock grazing system on tall fescue pasture planted under widely spaced black walnut trees yielded over sixfold greater present net worth than the comparable system in the open. It was found that tall fescue production under the canopy provided by black walnut trees was somewhat greater than in the open. Increased yield was also accompanied by increased percentage digestibility.

The growth of tall fescue pasture and black walnut under managed conditions is both biologically feasible and economically sound. This management has important implications relative to economic gains from improvement of permanent pastures by dampening the effects of fluctuating livestock prices through the stability of a long-term investment such as the timber resource.

Key words: black walnut, *Juglans nigra* L. tall fescue, *Festuca arundinacea* Schreb., multicropping.

14-2-4 Contribution of White Clover to the Economics and Energy Requirements of Grass-Based Beef Production Systems in the United Kingdom

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Approximately one quarter of the total energy consumed by UK agriculture is used in producing inorganic fertilisers, particularly nitrogen. As the cost of energy continues to rise, alternative systems, based on lower inputs and the effective utilisation of legumes, may become increasingly important.

The farm scale project reported here was designed to evaluate the role of white clover in grass swards for beef production and to compare the physical and economic output of such a beef system with that from a similar system receiving high inputs of N fertiliser. The energy utilisation of the two systems was also compared.

A 15 ha area was seeded to an S24 perennial ryegrass/Blanca white clover mixture in 1976 at two sites with contrasting soil types. The area at each location was then subdivided into two 7.5 ha blocks which were managed in a similar manner except for the level of N input. One block received 50 kg N/ha in the spring only and relied on white clover for its N requirements for the rest of the season (low N system). The other block received 300 kg N/ha spread over the growing season (high N system). Herbage from both blocks was utilised by autumn born Friesian steers which were introduced to the systems in April weighing approximately 200 kg. Each unit grazed the animals from April to end of October and also produced enough silage to fatten the animals at 16-18 months of age. Stocking rates were chosen to match the likely output from each system -- 3.3 animals/ha on low N area and 4.5 animals/ha on high N area. Measurements taken over the past 3 production cycles confirmed that both groups have similar amounts of herbage on offer during the grazing season.

Management of the clover dominant swards proved to be no more difficult than management of the high N swards and no disorders, such as bloat, were encountered even though the clover content at times reached 50% of the total herbage dry matter. Individual animal performance was consistently improved by approximately 0.1 kg/day on the clover swards, resulting in heavier carcasses at slaughter. However, because the low N system carried fewer stock it produced less beef per hectare than the high N system (a 3-year average of 830 kg liveweight gain/ha from the low N area compared with 990 kg/ha from the high N area). In current UK economic terms the lower output from the low N clover system can be more profitable than the more intensive high N system in certain circumstances. In terms of the ratio of energy input to energy output, the low N system was 50% more efficient than the high N system. The results suggest that legumes, such as white clover, could have a positive role to play in future UK beef production systems.

Key words: beef production, legumes, nitrogen fertilization, energy requirements.

14-3-1 Efficiency of Dairying Under Contrasting Feeding and Management Systems in North America, Israel, Europe and New Zealand

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Four different systems of feeding and managing dairy cattle are seen in major milk producing countries. These are : feeding purchased roughages and concentrates to zero-grazed intensively-penned cows (FPZG); home growing of roughages and most concentrates for zero grazed animals (HGZG); feeding concentrates with conserved pasture and other roughages in winter and reduced concentrates to grazed cattle in spring/summer (P + C); feeding cattle on grazed pasture and conserved pasture throughout the year (P). The following data on the FPZG, HGZG, P + C and P were obtained from the systems as practised in southern California, Wisconsin, England/Wales and N.Z.

Average FCM/cow is approximately 7140, 5300, 4670 and 3475 kg; output/ha 4700-10000, 4400-5300, 5200-5800 and 7000 ℓ FCM; and hours/cow 60, 70, 48 and 30 for the FPZG, HGZG, P + C and P systems respectively. In energy output/input, the P system is probably 3-4 times as efficient as any of the others.

Milk production costs in N.Z. are only about 40% of those in the U.S. and U.K. and it was calculated that dairy products from N.Z. could be landed in the U.S. at about two-thirds the cost of locally manufactured products. Much higher costs are incurred by countries such as Israel and Japan which have to import feed and fuel.

The protection of local dairy industries from competitive imports is leading to the need for subsidies, quotas on production and a reduction in milk consumption, and to a decline in the production of dairy products from temperate grasslands.

Key words: efficiency, feeds, dairy, North America, Israel, Europe, New Zealand.

14-3-2 Impact on Energy Budgets in Grassland Production and Conservation of the Possible Production of Energy from Biomass Crops

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There is commonly a conflict between output per unit area of land and output per unit of support energy (SE) input. The possibility of using a proportion of the total land area for biomass energy production suggests an approach for calculating grassland outputs per ha unconfounded with differences in SE input. Output can be calculated for an area of land which is devoted to grassland and biomass energy crops in proportions that result in a net demand for SE of zero.

Outputs of utilized metabolizable energy (UME) are related to inputs of SE for (i) grazed grass with high applications of nitrogen (N) fertilizer in comparison with grass-white clover without N fertilizer and (ii) the conservation of grass by different methods. SE inputs in fuel, fertilizers, technical chemicals and in the manufacture and maintenance of machinery and buildings are calculated. The biomass crop considered is a short-rotation forest (SRF) giving a yield of 12.5 t DM/ha and a net SE output of 195.5 GJ/ha.

For grass with N and grass-clover, the annual SE inputs are calculated as 33 and 2 GJ/ha respectively giving UME outputs of 102 and 78 GJ per ha and UME output:SE input ratios of 3.1 and 37.1 respectively. The area of SRF required would be 0.17 and 0.01 ha per ha grassland respectively. The UME outputs per ha total land area (grassland + SRF) then become 87 and 77 for grass with high N and grass-clover respectively.

A single cut of grass of 5 t DM per ha is considered to be conserved as silage, field-cured hay or barn-dried hay. The energy inputs for production and conservation are 17, 12 and 25 GJ/ha respectively to give UME outputs of 40, 30 and 39 GJ/ha and UME output to SE input ratios of 2.3, 2.6 and 1.6 respectively. However, when adjusted for the required area of SRF, the UME outputs become 37, 28 and 35 GJ/ha for silage, field-cured hay and barn-dried hay respectively.

These calculations suggest that the adoption of grassland systems with a high ratio for UME output:SE input may not improve land use when the requirements both for animal feed and SE are considered. If levels of UME output per ha are low, then the area of land required for animal feed production will be high. More intensive production systems using a smaller land area coupled with biomass energy production on the remaining area, may be the most appropriate strategy.

Key words: grassland production, grass, legume, grazing, silage, hay, support energy, biomass, short-rotation forestry.

14-3-3

Economic Analysis of the Impact of Management Decisions on the Production and Use of Silage for a Dairy Enterprise

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The aim of this work was to examine the influence of variations in grass management and methods of ensiling on the economics of milk production from autumn-calving cows.

A simulation model was developed to combine knowledge of plant and animal responses and their interactions in order to calculate the effects of management options on economic balances. Input data were compiled for herbage production from cutting strategies which gave herbage at four digestibilities, at two levels of applied nitrogen and in three climates. Experimental evidence was also collated to construct matrices of loss of dry matter and changes in digestibility and intake when herbage of different qualities is ensiled using any combination of the following options at harvest: flail or precision-chop harvester, wilting in the field or not, and using additive or not. The model combines the herbage production data with the matrices for ensiling method to give values for the yield and quality of silage produced by each management option (192 combinations in all). A feeding programme establishes for each silage the total requirements for silage and supplements of barley and soya bean meal for cows achieving potential yield, maximising silage use and minimising the cost of supplements. Margins are calculated for the value of milk minus the cost of supplements and silage in each option. Costs cover any items which vary between options.

When herbage yields appropriate to conditions in the U.K. were used in the model with costs and values current in the 1979/80 season, significantly greater margins resulted from 350 kg of N per ha than from 150 kg. In comparing cutting strategies the highest margins per cow were often associated with the use of herbage cut at 66.5 D value (Digestible organic matter as a percentage of the dry matter) while on the other hand the highest margin per ha of grass came from 61.5 D value. When these margins were expressed per ha of grass plus land for the barley used as supplement, the optimum value for digestibility again rose to 66.5 or 64 D. The effect of digestibility at cutting was less at the high level of applied nitrogen than at the low level.

The model enabled factors with critical financial impact to be identified for a particular economic environment. It is of value in considering national strategies, in influencing the direction of future research and in the analysis of problems on a particular farm.

Key words: simulation model, economic balances, herbage production, ensilage, digestibility, manuring, dairy cows, perennial ryegrass, Lolium perenne.

14-3-4 Machinery Selection and Management for Forage Harvesting Systems

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Dairy and beef nerdsmen must remain competitive in times of increasing grain demand. They could reduce their need for grain and oil-cake supplements by producing high quality forages. Good harvesting and storage practices play an important role in maintaining forage quality.

Research at the Agricultural Engineering Department of Michigan State University over the last two years has focused on computer modeling of forage harvesting operations and on field studies related to drying and dry matter losses of hay under various machinery management sequences.

For a given farm size and forage crop rotation, the computer model selects the number and size of machines for forage harvesting, transport and handling on the farmstead. The model has been helpful in assessing the large number of technologies available for forage harvesting and handling. It has also pointed out the areas where further knowledge is required: weather analysis to locate periods of consecutive dry days and improve field drying cycle time for machines such as bale and forage unloaders; the effect of harvest treatment and storage and feeding losses.

Field experiments of alfalfa harvesting were done in the Upper Peninsula of Michigan during the summer of 1980. Under a relatively cool and wet climate, various machinery sequences were compared as they affected drying rate and dry matter losses. Making dry hay during the June first cut seemed very difficult because of slow drying and a high risk of rain. The second cut, at the end of July, appeared as more favorable for hay making although there still remained some risk of quality deterioration due to rainfall.

Leaving freshly mowed, well-conditioned alfalfa in a wide swath and raking it one or two days later appeared as the best machinery sequence in a humid climate. Such a treatment had the fastest drying rate and could save one or more days of field curing compared with alfalfa windrowed at mowing time. Extra dry matter losses due to severe conditioning and raking amounted up to 3 or 4% of total dry matter yield. Reducing field exposure time and the risk of having weather-beaten, lesser quality hay might well compensate these relatively small yield losses.

Key words: harvesting, machinery management, machinery selection, hay making.

AUTHOR INDEX

Abo-Hassan, A. A., 84.
Abdouli, H., 399.
Abramides, P. L. G., 36.
Abrams, S. M., 271.
Adams, J. C., 177.
Afanasiev, R. A., 249.
Ahring, R. M., 13.
Aken'Ova, M. E., 80, 99, 427.
Akin, D. E., 272.
Akiyama, T., 255.
Albrecht, S. L., 143.
Alcantara, P. B., 36, 92, 425.
Alcantara, V. B. G., 36, 92, 425.
Aldrich, D. T. A., 262.
Allen, V. G., 230.
Allison, C. D., 364.
Almeida, J. E., 92.
Ambasht, R. S., 219.
Anderson, P. M., 358.
Ando, T., 127.
Andrade, R., 109.
Andreev, N. G., 224.
Andrews, A. C., 432.
Andrieu, J., 362, 387.
Angus, J. F., 254.
Argel, P. J., 183.
Arias, P., 411.
Arualds, A., 243.
Arthaud, R. L., 445.
Asay, K. H., 24, 371.
Asher, C. J., 112.
Aston, K., 382.
Ataku, K., 361.

Baba, K., 260.
Babalola, O., 427!
Baker, B. S., 394, 455.
Baker, C. J., 289.
Baker, R. D., 449.
Ball, P. R., 152.
Balla, E. F., 375
Banner, R. E., 454.
Barker, R. E., 82, 90.
Barnes, D. K., 148, 311.
Barnes, R. F., 286.
Barnett, O. W., 62.
Barnhart, S. K., 290.
Barnhisel, R. I., 163.
Barreto, I. L., 335.
Bartholomew, P., 414.
Barton, F. E. II, 284.
Bashaw, E. C., 52.
Bayley, P., 342.
Baylor, J. E., 464.
Beale, P. E., 18, 19.
Bedell, T. E., 444.
Beliuchenko, I. S., 184.
Belyea, R. L., 273
Ben Dhia, M., 399.
Benitez, D., 408.
Bennett, O. L., 394.
Berdahl, J. D., 82, 90.
Berger, L. L., 338, 340, 391.
Berkenkamp, W. B., 91.
Bernal, J., 102.
Billore, S. K., 220.
Bircham, J. S., 332.
Bishop, H. G., 297.
Bjugstad, A. J., 306.
Blagoveschensky, G. V., 227.
Blair, B. O., 122.
Blaser, R. E., 336.
Boatman, N. D., 291.
Bochniarz, J., 225.
Boeker, P., 305.
Boer, H., 269.
Boling, J. A., 42, 401.
Boller, B. C., 196.
Bonnefoy, G., 446.
Boonman, J. G., 210.
Bosma, A. H., 359.
Bouton, J. H., 51, 197.
Bowley, S. R., 15.
Boyce, K. G., 96.
Boyd, A. G., 287.
Boyd, W. E., 443.
Bragg, T. B., 159.

Bransby, D. I., 276, 409.
Breaux, J. K., 342.
Brereton, A. J., 322.
Breunig, K., 316.
Britton, R. A., 338, 357.
Brock, J. L., 150.
Brook, R. C., 472.
Brooks, W. H. III, 441.
Brougham, R. W., 5.
Brown, C. J., 264.
Brown, H., 51.
Brown, K. R., 105.
Brown, R. H., 197.
Brown, R. R., 108.
Bryan, W. B., 288, 415.
Bryant, H. T., 336.
Buckner, R. C., 42, 401.
Bull, L. S., 360.
Burdick, D., 284, 349.
Burns, J. C., 265, 285.
Burrows, V. D., 91.
Burrus, P. B. II, 42.
Burson, B. L., 44, 48, 52.
Burton, G. W., 29.
Burton, R. O. Jr., 415.
Bush, L. P., 42, 401.
Butler, J. E., 104.
Butts, W. T., 281.
Byerly, K. F., 452.
Byrd, N. A., 168.

Cabrales, R., 102.
Calderon, M., 428.
Calzadilla, D., 386.
Campbell, W. V., 320.
Campino, I., 142.
Cardenas, M., 93.
Carlisle, R. J., 392.
Carlson, I. T., 66.
Carter, E. D., 232.
Catchpoole, V. R., 153.
Caudle, A. B., 403.
Ceccarelli, S., 107.
Chadhokar, P. A., 38.
Chamblee, D. S., 320
Chaney, R. L., 173.
Chantkam, S., 112.
Chapman, P. F., 346.
Chatel, D. L., 19.
Chaves, C. M., 271.
Chen, Q., 239, 253.
Cheng, K. -J., 73, 395.
Chheda, H. R., 80, 99, 144, 427.
Chia, S. S., 330.
Chilcote, D. O., 97.
Chisholm, T. S., 368.
Chou, Dian-hui, 267.
Christensen, C., 319.
Christensen, D. K., 66.
Chu, T. C., 413.
Ciordia, H., 403.
Clemence, T. G. A., 98.
Clements, R. O., 318.
Cochrane, T. T., 166.
Cock, J. H., 398.
Cohen, R. D. H., 372.
Colby, W. G., 134.
Collins, G. B., 46, 47.
Collins, M., 326, 350, 354.
Collins, W. J., 19.
Combellas, J., 411.
Conrad, H. R., 380.
Cooper, J. P., 8.
Cope, W. A., 62.
Cordova, F. J., 377.
Cornelius, P. L., 46.
Corrall, A. J., 471.
Costa, A. C., 416.
Costerton, J. W., 395.
Coto, G., 280.
Coughenour, M. B., 242.
Couto, W., 140, 419.
Cox, N. R., 385.
Craven, R. H., 465.
Crawford, E. J., 74.
Crowder, W., 108.
Cruz Filho, A. B., 67
Cunningham, G. L., 189.
Curnow, B. C., 19.
Curll, M. L., 236.
Currie, P. O., 302, 371.
Currier, C. G., 25.

Daley, S. R., 382.
Dalrymple, R. L., 400.
Damiani, F., 107.
Daniel, P., 259.
da Rocha, C. M. C., 419.
da Rocha, G. L., 36, 425.
Daughtry, C. S. T., 202.
Davidson, J. P., 173.
de Andrade, R. P., 56, 419.
Debska-Kalinowska, Z., 157.
Decker, A. M., 173, 293.
Dehority, B. A., 380.
Deinum, B., 195, 269.
Demarquilly, C., 362, 387.
Dewald, C. L., 13.
Dewey, D. R., 24.
Diaz, L. E., 81.
Dirven, J. G. P., 304.
Donart, G. B., 203, 377.
Dornfeld, D., 461.
Dougherty, C. T., 235, 325.
do Valle Ribeiro, M. A., 86.
Dovrat, A., 313.
Drake, M., 134.
Dudley, R. F., 293.
Dulphy, J. P., 387.
Dwyer, D. D., 458.

Eardly, B. D., 208.
Echimane, B., 65.
Edgar, K. F., 116.
Edwards, D. G., 112.
Edwards, P. J., 7, 414.
Elgin, J. H. Jr., 283.
Elias, A., 374, 408.
Elkins, C. B., 23, 25.
Ely, D. G., 402.
Ely, L. O., 270, 348.
Embry, L. B., 368.
Enne, G., 331.
Eric, P., 179.
Erickson, D. O., 77.
Eschavarria, S., 252.
Escuder, C. J., 406.
Estell, R. E., 281.
Evans, J. K., 453.
Evans, J. L., 261.
Everett, H. W., 156.
Evers, G. W., 212.

Fahey, G. C. Jr., 340.
Falcinelli, M., 107.
Fales, S. L., 202.
Fallstocco, E., 89.
Falkowski, J., 118.
Falkowski, M., 88.
Falvey, J. L., 430.
Farmer, M. J., 389.
Farrier, D. S., 137.
Faulkner, J. S., 69.
Favoretto, V., 308.
Fay, J. P., 73, 395.
Feigin, A., 119.
Fejer, S. O., 91.
Ferguson, J. E., 109.
Fick, G. W., 256.
Field, T., 200.
Fienup, D. F., 459.
Fisher, M. J., 190.
Fishman, M. L., 349.
Fissel, G. W., 283.
Fisser, H. G., 205, 451.
Fleming, S. C., 326.
Fletcher, R. H., 150.
Fontenot, J. P., 336.
Foster, A. E., 77.
Frame, J., 116, 287.
Francis, C. M., 19.
Frank, A. B., 192.
Fransen, S. C., 368.
Fribourg, H. A., 392.
Fritz, J., 339.
Fuenzalida, E. F., 460.
Fukunaga, K., 134.
Funes, F. A., 81.

Gallais, A., 65.
Gallardo, A., 174.
Garcia, R., 386.
Garden, D. L., 372.
Gardener, C. J., 420, 421.

Garrett, H. E., 467.
Gaskins, M. H., 143.
Geerken, C. M., 280, 386.
Gemma, T., 309.
Genckan, M. S., 217.
Genevini, P. L., 331.
Gerrish, J. R., 235.
Ghiasud-Din, M., 231.
Gibbens, R. P., 222.
Gibbon, C. N., 106.
Gibson, P. B., 62.
Gibson, T., 431.
Giesbrecht, F. G., 265.
Gillespie, D. J., 14, 19, 28.
Gillet, M., 40.
Giraud, P., 40.
Gladstone, J. S., 19.
Glenn, B. P., 402.
Glenn, S., 402.
Godfrey, E. B., 129.
Goelz, M. F. B., 78.
Goetz, H., 244.
Gomes, D. T., 419.
Gomez Pitera, C., 101.
Goncalez, D. A., 437.
Goold, G. J., 334.
Goplen, B. P., 73, 395.
Gorz, H. J., 39.
Grajewski, J., 347.
Gramshaw, D., 20, 187.
Granova, L. A., 344.
Green, J. O., 175.
Grenet, E., 362.
Griffin, J. L., 263.
Grof, B., 94.
Groves, R. H., 312.
Grynia, M., 206.
Gudmundsson, O., 243.
Guessous, F., 251.
Gurevitch, J., 223.
Gustine, D. L., 405.
Gutteridge, R. C., 75.
Guy, P., 65.

Haaland, R. L., 23, 25, 447.
Habovstiak, J., 366.
Haenel, V., 355.
Hagedorn, C., 145.
Haggar, R. J., 291.
Hakkola, H., 329.
Hale, O. D., 352.
Halverson, S. D., 168.
Hammes, R. C. Jr., 336.
Hammond, R. C., 173.
Han, I. -K., 397.
Hanna, W. W., 43.
Hansen, C. M., 353.
Hanson, J. D., 191, 376, 379.
Harada, I., 120.
Harkess, R. D., 116, 287.
Harlan, J. C., 443.
Harlan, J. R., 2.
Harper, L. A., 153.
Harpster, H. W., 358.
Hart, R. H., 375.
Hartadi, H., 271.
Harvey, R. W., 265.
Hasbargen, P., 465.
Hasbargen, P. R., 445.
Hasegawa, M., 134.
Haskins, F. A., 39.
Hauser, V. L., 301.
Haussmann, G., 180.
Hebblethwaite, P. D., 98.
Hedges, D. A., 390.
Heichel, G. H., 148.
Helsel, Z., 353.
Hembry, F. G., 230.
Hemken, R. W., 42, 360, 401.
Henderlong, P. R., 208.
Henderson, I. F., 318.
Hendrix, K. S., 343.
Henkel, W., 316.
Henry, D. S., 164.
Henry, J., 108.
Henzell, E. F., 4.
Herrera, R. S., 35.
Hertel, J. M., 343.
Hides, D. H., 32.
Hill, M. J., 12.
Hill, R. R., Jr., 21.
Hodges, E. M., 404.
Hodgson, J., 332.

Hof, G., 269.
Hoffman, L. D., 358.
Hofmann, L., 328.
Hoglund, J. H., 150.
Hollick, A. M., 416.
Holloway, J. W., 281.
Holt, D. A., 202, 351.
Holt, E. C., 248.
Honig, H., 356.
Horigome, T., 171.
Horiguchi, M., 361.
Horn, G. W., 337.
Horrell, C. R., 418.
Horton, G. M. J., 389.
Hosking, W. J., 128.
Hoveland, C. S., 23, 25, 447.
Howard, W. T., 461.
Howarth, R. E., 73, 395.
Hu, Z., 167.
Huang, C., 413.
Huang, W., 57.
Hubbell, D. H., 143.
Huck, M. G., 447.
Hughes, P. M., 382.
Humphreys, L. R., 182, 183, 412.
Hunt, W., 200.
Hunter, J. M., 124.
Huokuna, E., 329.
Hur, S. H., 185.
Hutton, E. M., 71.

Ibrahim, K. M., 83.
Iglovicov, V., 114.
Ingram, J., 262.
Inskeep, E. K., 455.
Iruleghi, G. S., 237.
Ison, R. L., 182.
Ivory, D. A., 27.

Jackson, J. A. Jr., 42, 401.
Jacobs, J. J., 466.
Jacobson, E. T., 82.
Jain, H. K., 216, 440.
Janas, J., 347.
Jauhar, P. P., 55.
Jayawardana, A. B. P., 433.
Jerez, I., 407.
Johnson, D. A., 250.
Johnson, J. T., 336.
Johnson, P. S., 240.
Johnson, T. R., 353.
Johnson, Z. B., 264.
Jones, H. R., 124.
Jones, J. H., 169.
Jones, M. B., 121.
Jones, R. J., 421.
Jordan, H., 374.
Jorgensen, N. A., 286, 326, 354
Joshi, J. K., 115.
Joyce, L. A., 221.
Jump, R. C., 258, 376.
Jung, G. A., 263.
Jutzi, S., 109.

Kaczynska, B., 225.
Kalmbacher, R. S., 298.
Kaltofen, H., 70.
Kang, M. -H., 397.
Kang, T. -H., 397.
Karlovsky, J., 110.
Karn, J. F., 328.
Kasprzykowska, M., 225.
Katic, S., 218.
Kawabata, S., 68.
Kaye, P. E., 312.
Kayouli, C., 399.
Keeney, D. R., 152.
Kemmler, G., 134.
Kemp, P. R., 189.
Kendall, W. A., 78.
Kenny, P. T., 393.
Khan, E. J. A., 416, 429.
Kilcher, M. R., 370.
Kim, D. A., 185.
Kim, Y. J., 185.
Kipnis, T., 119, 313.
Kirkham, M. B., 193.
Kismono, I., 126.
Kitchen, L., 402.
Kjelgaard, W. L., 358.

Klesnil, A., 132, 294.
Klinner, W. E., 352.
Klopfenstein, T. J., 338, 341, 357, 391.
Knabe, O., 279.
Knight, W. E., 62, 145, 149.
Kobayashi, H., 204.
Koch, D. W., 291, 292.
Koegal, R. G., 354.
Koehler, G., 103.
Koenigs, R. L., 121.
Koev, K. I., 135.
Kornher, A., 254.
Korotkov, B. I., 315.
Koster, H. W., 416.
Kotham, M. M., 364.
Kothmann, M. M., 277.
Kozlowski, S., 88.
Kouno, K., 127.
Kreider, D. L., 264.
Kreil, W., 135.
Kretschmer, A. E. Jr., 125, 435.
Krupinsky, J. M., 82.
Kryszak, A., 206.
Kubo, S., 266.
Kuenstler, W. F., 164.
Kuhbauch, W., 463.
Kukulka, I., 88.
Kulakov, V., 114.
Kurtz, W. B., 467.

Lacefield, G. D., 453.
Ladisch, M. R., 339.
Lana, K., 245.
Lancashire, J. A., 323.
Laniewska, B., 225.
Lantinga, E., 195.
Lanyon, L. E., 464.
Latterell, R. L., 49.
Lawrence, T., 370.
Laycock, W. A., 170.
Lazenby, A., 6.
Leafe, E. L., 194.
Leath, K. T., 317.
Lechtenberg, V. L., 202, 339, 343, 351.
Le Du, Y. L. P., 278, 449.
Lees, G. L., 73, 395.
Lenne, J. M., 321.
Leone, A., 174.
Lewicka, E., 157.
Lewis, P. E., 394, 455.
Li, C., 214.
Li, J., 209.
Li, M., 58.
Liang, J., 165.
Lighter, J. W., 122.
Lin, K. W., 339.
Linden, J. C., 34.
Liseu, L. C., 439.
Lloyd, D. L., 20.
Locatelli, C., 180.
Lopez, M., 93.
Lorenz, R. J., 59.
Lorenzetti, F., 67, 89.
Lowe, K. F., 20.
Lowther, W. L., 295.
Lucas, L. T., 320.
Ludlow, M. M., 190.
Lueschen, W. E., 311.
Lugg, D. G., 189.
Lush, W. M., 312.
Lyduch, L., 118.
Lyons, T. B., 323.

Machado, H., 85.
Muchler, F., 196.
Maeng, W. J., 268.
Mahoney, G. P., 124.
Majak, W., 73, 395.
Majdoub, A., 399.
Makarenko, P. S., 198.
Manda, T., 345.
Mappledoram, B. D., 414.
Maraschin, G. E., 237.
Marchenko, O. S., 303.
Mark, W. H., 429.
Marten, G. C., 283.
Martin, F. G., 274, 404.
Martin, M., 40.
Martin, N. P., 311, 445, 465.
Martinez, R. A., 452.

Martins, M., 436.
Martins, P. S., 61, 63.
Martyn, R. S., 96.
Martz, F. A., 273.
Masaoka, Y., 33, 345.
Matches, A. G., 273.
Matsumoto, T., 361.
Maxwell, R. H., 455.
Mays, D. A., 336.
Mbugua, P. N., 388.
McClaugherty, F., 336.
McCown, R. L., 420.
McDaniel, K. C., 442.
McDonnell, M. L., 391.
McGinnies, W. J., 162.
McHan, F., 349.
McIvor, J. G., 421.
McKeon, G. M., 422.
McLaren, J. B., 392.
McNaughton, S. J., 242.
McWilliam, J. R., 106.
Mecelis, N., 308.
Meijs, J. A. C., 363.
Mela, T., 227.
Mella, S. C., 237.
Melton, B. E., 389.
Menchaca, M. A., 407.
Mengel, D. B., 122
Merrill, J., 357.
Mertens, D. R., 270.
Merzlaja, G. E., 249.
Meyer, D. W., 77.
Michalk, D. L., 275, 423.
Mijatovic, M., 218.
Mikled, C., 324.
Mikolajczaj, J., 347.
Miles, A. D., 211.
Miller, J. D., 62.
Minson, D. J., I.
Miskovic, B., 179.
Mislevy, P., 274, 404.
Misra, K. N., 219.
Moeller, N. J., 383.
Mohamed Saleem, M. A., 80.
Mohanty, S. B., 173.
Monreal, A. R., 16.
Moon, N. J., 348.
Moore, C. P., 398, 419.
Moore, J. E., 271, 285.
Moore, K. J., 343.
Moore, T. S., 137.
Mora, M. I., 340.
Morales, J. L., 252.
Moser, L. E., 181
Mott, G. O., 3, 274.
Mou, X., 167.
Moyer, B. G., 405.
Mukhiya, Y. K., 115.
Mulcahy, C., 390.
Muldoon, D. K., 87.
Mundel, G., 135.
Murphy, A. H., 121.
Murphy, P. M., 147.
Murphy, W. E., 130.
Myers, R. J. K., 153.

Neal, H. D. St. C., 471
Nelson, C. J., 181, 199.
Nelson, L. R., 79.
Neretina, T. V., 227.
Neuteboom, J., 304.
Nicholas, D. A., 19, 28.
Nicholas, P. J., 162.
Nikki, I., 10.
Nitis, I. M., 245.
Nitzsche, L. W., 41.
Noel, C., 40.
Nojima, H., 228.
Noller, C. H., 122, 383.
Noller, K., 339.
Nordestgaard, A. G., 95.
Norman, M. J. T., 324.
Norris, K. H., 283.
Norton, B. E., 240.
Nosberger, J., 196.
Nyren, P. E., 244.

Ocumpaugh, W. R., 438.
Odu, C. T. I., 144.
Odum, J. W., 25.
Ogata, S., 127.
Oizumi, H., 228

Okoli, B. E., 54.
Okubo, T., 255.
O'Leary, J., 360.
Olivares, A., 226.
Oliveira, E. M. P., 63.
Olivo, C. J., 335.
Olorode, O., 54.
Olsen, F. J., 169.
Onokpise, O. U., 72.
Onstad, D., 256.
Oohara, H., 134.
Oohara, Y., 450.
Orodho, A., 83.
O'Rourke, J. T., 454.
Ortega, C. M., 307.
Osetsky, S. I., 198.
O'Sullivan, M., 365.
Owens, F. N., 337.
Owens, M. K., 205.
Owensby, C. E., 377.

Pandeya, S. C., 426.
Panella, A., 89.
Paoletti, R., 180.
Paollichi, P. M., 416.
Paretas, J. J., 93, 133.
Park, B. H., 201.
Park, C. M., 185.
Parr, C. R., 385.
Parrini, P., 67.
Parsons, A. J., 194.
Paterson, J. A., 391.
Paterson, R. T., 418.
Paves'c-Popovic, J., 218.
Pearce, R. B., 66.
Pearson, C. J., 12, 324.
Pearson, H. A., 168.
Peel, S., 175.
Peischel, A., 377.
Pendleton, D. F., 462.
Perez, A., 252.
Perez-Infante, F., 381.
Peters, E. J., 296.
Petersen, M. M., 160.
Peterson, H. L., 149.
Phillips, D. V., 231.
Phillips, G. C., 47.
Phipps, R. H., 37.
Piano, E., 111.
Pieper, R. D., 203, 241, 377.
Pinchak, W. E., 369.
Pitcock, J., 46.
Pitera, C. G., 16.
Pitman, W. D., 248.
Pizarro, E. A., 436, 439.
Podkowka, W., 347.
Porceddu, E., 67.
Powell, J. L., 163.
Primo, A., 410.
Prine, G. M., 60.
Prins, W. H., 131.
Prinsen, J. H., 422.
Probasco, G. E., 306.

Quesenberry, K. H., 438.
Quin, B. G., 141.
Quiroga, M., 452.

Ramos Monreal, A., 101.
Ramos, R., 35.
Ramosevac, I., 64.
Rand, H., 329.
Ream, H. W., 354.
Reed, K. F. M., 393.
Ren, J., 167.
Rhykerd, C. L., 122, 383.
Riboldi, J., 237.
Richter, K., 316.
Rickard, D. S., 141.
Rickert, K. G., 422.
Rieck, C. E., 402.
Ries, R. E., 59.
Rittenhouse, L. R., 364.
Riveros, E., 226.
Robards, G., 275.
Robards, G. E., 423.
Robb, T. W., 402.
Robinson, D. L., 230.
Rock, D., 357.
Rodgers, D. E., 451.
Rodriguez-Kabana, R., 23.

Roehrkasse, G., 177.
Rohr, K., 356.
Rohweder, D. A., 286, 461.
Rolim, F. A., 416.
Rotili, P., 76.
Rouquette, F. M. Jr., 79.
Ruelke, O. C., 438.
Ruiz, R., 280, 386.
Rumbaugh, M. D., 250.
Rutherford, M. T., 297, 373.
Rutkowska, B., 157.
Ryan, M., 333.

Saiga, S., 31.
Saito, H. M., 416.
Saleem, M. A. M., 427.
Samudio, C., 307.
Sanders, S. A., 164.
Sandow, J. D., 14.
Sanzonowics, C., 140.
Saric, O., 64.
Saukevicius, B. P., 151.
Sauvion, A., 65.
Savage, G. F. J., 128.
Savidan, Y. H., 53.
Savoie, P., 47, 472.
Scarnecchia, D. L., 277.
Schalitz, G., 316.
Schalles, R. R., 377.
Scheaffer, C. C., 311.
Schehovic, J., 40.
Sciaraffia, F., 331.
Scott, J. D. J., 469.
Scott, R. S., 295.
Segui, E., 85.
Seif, S. A., 351.
Seitlheko, M., 188.
Selim, H. M., 230
Senra, A., 381.
Serrao, E.,A., 417.
Sexton, J. C., 137.
Seyfarth, W., 279.
Sha, Q., 165.
Shaffer, D., 339.
Shalhevet, J., 119.
Shane, R. C., 368.
Shapkin, A., 114.
Sharp, W. M., 337.
Shatilov, I. S., 213
Scheglov, V. V., 282
Shenk, J. S., 283
Sherwood, M., 154.
Shibata, Y., 260.
Shinohara, I., 120.
Shirley, J. E., 261.
Shiyomi, M., 255, 266.
Simon, U., 201, 259.
Singh, A. K., 219.
Singh, N. T., 138.
Singh, R., 138.
Singh, V. P., 115, 155.
Siregar, M. E., 188.
Skiles, J. W., 172.
Skinner, Q. D., 137, 177.
Sklane, S., 389.
Sleeper, J., 454.
Sleper, D. A., 199, 273.
Smith, A. E., 231.
Smith, D. H., 34.
Smith, F. W., 113.
Smith, G. R., 149.
Smith, M. A., 177, 369.
Smith, R. R., 17.
Snyder, G. H., 125, 435.
Solomon, M. G., 144.
Southwood, O. R., 19.
Souza-Costa, N., 109.
Speck, J. E. Jr., 177.
Springer, T. L., 13.
Stallcup, O. T., 264, 342.
Stanko-Brodkowa, B., 157.
Stefanovic, L., 179.
Stern, W. R., 19.
Stevens, E. J., 176.
Stewart, T. A., 468.
Stiles, D. A., 335.
Stnand, O. E., 311.
Strafelda, J., 132, 294.
Streeter, C. L., 337.
Stuedemann, J. A., 310, 403.
Sudarmadj, 126.
Suginobu, K., 22.
Sullivan, G. J., 445.

Sullivan, G. M., 447.
Susetyo, S., 412, 126.
Sutherland, D. M., 159.
Suwoko, S. I., 126.
Suzuki, M., 186.
Suzuki, S., 68.

Takahashi, S., 255.
Takahata, S., 260.
Takano, N., 345.
Takasaki, Y., 228.
Tan, G. Y., 146.
Tarumoto, I., 33.
Tayeb, A. E. H., 314.
Taylor, N. L., 46, 47
Taylor, T. H., 234.
Templeton, W. C., 234.
Templeton, W. C. Jr., 283.
Terada, Y., 30.
Tesar, M. B., 353.
't Hart, M. L., 195.
Thomas, C., 382, 388.
Thomas, D., 56, 109, 419.
Thomas, G. W., 9, 457.
Thomas, J. W., 353.
Thomas, N., 452.
Thomas, R. J., 402.
Thompson, R. L., 311.
Thompson, W. C., 453.
Thons, H., 456.
Thorsteinsson, I., 243.
Tomes, D. T., 72.
Topark-Ngarm, A., 424.
Torssell, B. W. R., 254.
Townsend, C. E., 11, 49.
Traineau, R., 40.
Trigg, T. E., 385.
Tromble, J. M., 178.
Tunney, H., 117.
Twamley, B. E., 72.

Uchida, S., 171.
Ueno, M., 207.
Uexekuell, H. R., 134.
Ugarte, J., 381.

Upadhyaya, S. D., 155.

Vaisman, I., 119.
Valdes, L. R., 396.
Vance, C. P., 148.
Van der Aar, P. J., 269, 340.
Van der Honing, Y., 384.
Van der Meer, H. G., 434.
van Dijk, G. E., 26.
Van Dyne, G. M., 172, 258, 376, 379, 462.
Van Epps, G. A., 250.
van Es, A. J. H.,, 384.
Van Keuren, R. W., 380.
Van Scoyoc, G. E., 122.
Varga, P., 100.
Vartha, E. W., 238.
Vaughn, C. E., 121.
Velich, J., 132, 294.
Vello, N. A., 61.
Vera, R. R., 436, 439.
Vetter, R. J., 351.
Viana, J. A. C., 436.
Vickery, P. J., 229.
Vigil, F. R., 368.
Vilela, H., 410.
Villalta, P., 176.
Villet, R. H., 34.
Vincourt, P., 65.
Vogel, K. P., 39.
Voigt, P. W., 44, 52.
von Boberfeld, W. O., 305.
Vough, L. R., 293.

Wade, M. H., 278.
Waggoner, J. W., 369.
Walker, B., 297, 373.
Wallace, J. D., 377.
Wallace, L. L., 242
Ward, J., 341, 357.
Waters, W. K., 464.
Watt, L. A., 233.
Wedin, W. F., 151, 290, 450.
Weiland, G., 456.
Weller, R. F., 37.

West, C. P., 151.
Westerhaus, M. O., 283.
Wheeler, J. L., 229, 390.
White, L. M., 247.
White, R. S., 302, 371.
Whitehead, D. C., 139.
Whiteman, P. C., 188, 373, 412.
Whitney, A. S., 299.
Wieghart, M. A., 353.
Wight, J. R., 129.
Wildin, J. H., 300, 448.
Wilkins, R. J., 236, 346, 470.
Wilkinson, J. M., 346, 471.
Wilkinson, S. R., 310, 403.
Williams, C. B., 23.
Williams, C. M. J., 96.
Williams, D. E., 244.
Williams, E. G., 45.
Williams, W. M., 45.
Wilman, D., 123.
Wilson, J. R., 246.
Wilson, L. L., 358.
Wilson, R. F., 346.
Wilton, A. C., 59.
Winslow, D. F., 416.
Winter, W. H., 421.
Wisiol, K., 257.
Wojahn, E., 70, 135, 279, 456.
Wolf, D. D., 336.
Wolfe, E. C., 19.
Wright, C. E., 69.
Wright, P. T., 123.

Xiao, Y., 165.
Xu, S., 50.

Yamane, I., 204.
Yang, D., 209.
Yang, F., 239.
Yarlett, L. L., 367.
Yates, S. G., 401.
Ye, J., 214.
Yeh, T. P., 413.
York, J. O., 264.
Yoshida, N., 450.
Young, W. C. III, 97.
Youngberg, H. W., 97.
Yun, H. S., 268.
Yun, I. S., 268.

Zallar, S., 158.
Zannone, L., 76.
Zhang, P., 167.
Zhao, K., 214.
Zhao, S., 239, 253.
Zheng, X., 214.
Zimmer, E., 356.
Zhu, B., 215.
Zhu, T., 209.