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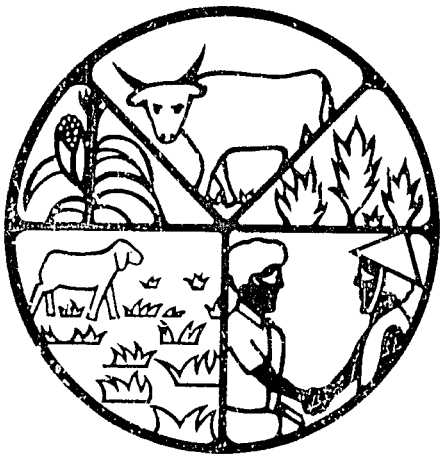
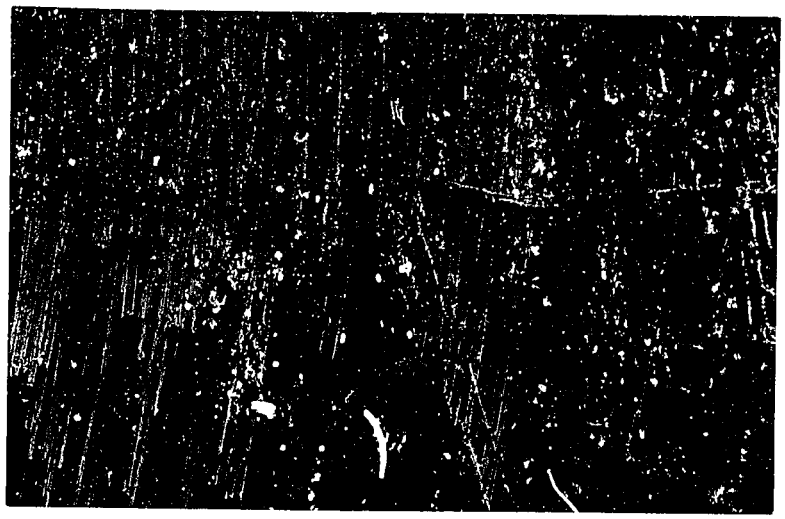
Mixed Farming Technical Report





GAMBIAN MIXED FARMING AND RESOURCE MANAGEMENT PROJECT

Ministry of Agriculture and
Natural Resources
Government of The Gambia

Consortium for International Development

Colorado State University

RESEARCH IN FORAGE AGRONOMY BY THE MIXED FARMING PROJECT, 1983-1986

by
Sandra L. Russo
and
Bambo Ceesay

Technical Report No. 12
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RESEARCH IN FORAGE AGRONOMY
BY THE MIXED FARMING PROJECT, 1983 - 1986

Summary

The forage production and management component was designed to increase the total vegetation available for grazing. Specific objectives were to:

1. survey information and materials about improved forage species in The Gambia;

2. introduce and evaluate cultivars of exotic tropical grass and legume species;

3. demonstrate potential of extending dry season grazing by introducing a forage legume into fallow lands and better utilization of groundnut hay;

4. conduct grazing and feeding trials;

5. develop a seed production program to increase supply of suitable and adaptable grass and legume species; and train Gambians in forage improvement.

6. train Gambians in forage improvement.

During the first half of the project, project forage agronomists worked on all of the above points with the exception of the demonstration of legumes used in fallow lands. Lack of seed, both imported and local, hampered village demonstrations of fodder banks and the use of legumes in fallow lands. Starting a seed multiplication program was also delayed until later in the project.

In the last half of the project, the project has devoted its forage agronomy efforts to experimental trials utilizing adapted forage legumes, crop residue feeding trials, grazing trials, village-level livestock feeding programs, herding studies, development of a forage legume seed multiplication unit at Sapu and continued training of Gambian staff.

After several years of testing, a few of the introduced forage legumes seem to be adapted to Gambian conditions. These are Stylosanthes hamata, humilis, guianensis, capitata and scabra and Leucaena leucocephala. Initial explorations concerning the use of these legumes as intercrops with cereals were started in 1984 and 1985. The advantages of a legume intercrop are multiple: provision of ground cover and weed control, possible nitrogen contribution to the soil and cereal crop and most importantly, provision of a feed resource for grazing or cutting after the cereal crop is harvested.

Crop residue feeding trials have shown that animal weights can at least be maintained over the dry season. Groundnut hay is the most efficacious feed for weight gains and its inclusion in rations of other crop residues boosts their nutritive value considerably.

Grazing trials with work oxen, sheep and goats have pinpointed those legumes most preferred by these livestock. Fortunately, these are the same legumes that are adapted to The Gambia, i.e., the Stylos mentioned above.

A collaborative effort with project range scientists and the Livestock Owners Associations in villages of McCarthy Island and Upper River Divisions on deferring and improving range lands and the saving and feeding of crop residues in the dry season has been very successful. Farmers outside the study areas are beginning to store and feed crop residues on their own, without benefit of project input, which is a positive sign of farmer acceptance.

A herding study conducted with MFP's field enumerators in four villages entailed the collection of information on herd ownership and management, distances traveled to water, grazing patterns and plants consumed. Crop residues provide a significant portion of the total year's feed supply while native grasses are the most prevalent forage eaten in bushlands.

Training activities were many and varied with three Gambians receiving B.S. degrees and several more benefiting from various short courses offered in The Gambia, Ethiopia and the U.S. These programs included farming systems research and extension methodology (University of Florida, FSSP), forage analysis and animal nutrition (ILCA, Ethiopia), plant identification and collections (Basse) and seed technology (Texas A&M, Beeville and University of Florida). Agricultural assistants assigned to the unit also received extensive on-the-job training in addition to short-term formal training.

The forage program is only in its infancy, with many years of research and extension efforts ahead of it. Recommendations include continued work on intercropping with legumes, feeding and grazing trials with all classes of livestock, establishment of seed multiplication and forage testing facilities and further training of Gambian staff.

Acknowledgements

For the forage program to have accomplished as much as it did in such a short time, several individuals in the Ministry of Agriculture had to put in a great deal of effort. Kutubo Sanyang and Lamin Jobe, Agricultural Assistants assigned to the forage component of the Mixed Farming Project did an excellent job of managing the day-to-day field operations and collecting of data. Mamadi Jawo, Amie Njie, Jam Samba and the late Pa

Ceesay were very helpful during the course of the feeding trials at the Farmyard. Bambo Ceesay, assigned as counterpart to the forage program, was instrumental in delivering the crop residue feeding program technology to Gambian farmers and in setting up a seed multiplication unit at Sapu.

The support of the Mixed Farming staff at Abuko is gratefully acknowledged, especially that of Dr. Glen Fulcher whose strength and guidance are greatly appreciated.

Special thanks are given to Gambian farmers and livestock owners who were always willing to take the time to discuss issues and problems.

Introduction

Livestock are a very important component of Gambian farming systems. All ruminant livestock, with the exception of draft animals, are extensively managed. Cattle in particular are often herded long distances for part of the year in search of sustenance. Livestock feed is derived from two sources either native or naturalized vegetation (grasses, shrubs, trees, forbs, rarely legumes) and crop residues left in the fields after harvest. Availability of livestock feed is one of the major constraints to improved livestock production in The Gambia. The Mixed Farming Project undertook to increase the livestock feed supply by developing an improved forage production and management program. A report by Hedrick and Bojang (1983) detailed this work from 1981 to mid-1983; this report summarizes the results of the entire forage program with emphasis on the last three years.

Prior to the work done by the Mixed Farming Project little recorded research had been done on forage and pasture species. Anecdotal information, observations of nonreplicated small plots and the naturalization of Stylosanthes indicated that someone at some time in the not-too-distant past had begun research on forage legumes. A major survey of The Gambia (Dunsmore et al, 1976 estimated the total dry season fodder resources as being able to provide for about 177,500 adult livestock equivalents annually. These resources came from: crop residues, floodplain grazing, early fallows and upland bushland. However, since 1974, the cattle population has increased from 200,000 to 300,000, the area of floodplain grazing has been reduced due to an increase in irrigated rice production, the annual population growth rate has been 2.4%, areas formerly left fallow are beginning to be continuously cropped and bush/forest lands are increasingly being brought under cultivation.

The forage component of the Mixed Farming Project has concentrated on several areas of improved forage production and management to impact the livestock feed situation. These are: improved legume and grass introductions, seed multiplication, experimental trials investigating clipping effects and the use of legumes as intercrops with cereal crops, grazing trials of improved legumes, research station and village-level feeding

trials of improved legumes, research station and village-level feeding trials (the latter in collaboration with the Range Unit), a herding study including plant collection and analysis, establishment of a small forage analysis laboratory and training of Gambian personnel.

Legume and grass introduction trials

Legumes

From 1982-1984, the forage program concentrated on legume introductions. Three sites were selected in the country for introduction and variety trials in 1982. The sites were at Yundum, Sapu and YBK and represent three of the major soil associations used for cropping in The Gambia. Limited seed supplies of the 15 legume varieties left some gaps in plantings at Sapu and YBK which were filled in 1983 using seed produced at Yundum. Also in 1983, half-hectare plantings of various legumes were added at four Mixed Farming Centers, the Mansakonko Rural Development Center and at the village of Boiram (Hedrick and Bojang, 1983).

Continued requests by the project for experimental quantities of seed from various sources led to a constant, if irregular, arrival of seed necessitating further introduction trials in 1983 and 1984 at Yundum. Over four dozen legume varieties and cultivars have been tested. The legumes tested were pre-selected for presumed adaptability to the soils and climatic conditions prevalent in this country but after four years of testing, less than half have survived and only a few of those can be said to be potentially useful under Gambian conditions.

Three factors have had the greatest influence on whether a legume successfully establishes here. These are amount and distribution of rainfall, competitiveness with weeds and resistance to insect and pest (including rodents) attack. Seeds were planted in a well prepared seed bed with small amounts of nitrogen and phosphorus fertilizer and were weeded at least twice in the first year of establishment. Full-time labor crews at Yundum, Sapu and YBK kept the introduction plots fairly free of weeds. However at the other sites labor was only sporadically available for weeding. For many of the legumes, especially Stylosanthes guianensis cultivars and Macrotyloma axillare, weed competition was too great. Other legumes succumbed to grassy weeds in the second year. The Leucaenas were very susceptible to termite and rodent attack. The Desmodium, Centrosema and Zornia species failed because of inadequate moisture for their growth and seed production.

The legumes were observed for a number of characteristics during these introduction trials. Parameters studied were dry matter yield (as measured by biomass dry weight, plant height and/or stand counts), time of flowering and whether the legumes were indeterminate or determinate, time and quantity of seed production, how far into the dry season the plant remained green, their overall survival ability and resistance in terms of weeding,

moisture, rhizobia and seed treatment requirements, whether the legume could be grazed in the first year of establishment, its success as an intercrop with cereal crops and animal preference. All of these characteristics for the tropical legumes that seem to have potential for The Gambia are listed in Tables 1a, 1b and 2.

Although these legumes all fall under the general heading of forage legumes they do not have to be used solely in pastures; they have multifarious uses and suitabilities for different farming systems. Some may be useful only in fodder banks, others in alley crops to be used as cut-and--carry feed or green mulch, still others as intercrops to be used for dry season grazing. An examination of these tables will assist in choosing the appropriate legume for a particular system. Further research is, of course, needed to determine the best use or uses of each legume. (Also see Figures 1 and 2.)

Table 1a. Growth and production characteristics of introduced tropical legumes.

CIAT accessions, 1982-83 plantings	DM yield	Flower-ing	Seed prod.	Green-ness	Survival ability	Insect resis.	Weed resis.	Estab. Ease	Graze 1st yr.	As Inter-crop	Animal preference
Stylosanthes humilis -L	G	D	G	Je-Feb	E	E	G	W,S	Yes,L	G	E
Stylosanthes hamata-A	G	D	F	Je-Dec	E	E	G	W,S	Yes,L	F	E
Stylosanthes hamata-L	G	D	G	Je-Feb	E	E	G	W,S	Yes,L	G	E
Stylosanthes scabra-A	E	D	F	Je-Apr	E	E	E	W,S	Yes	n.t.	F
Stylosanthes guianensis-A	F	D	F	Je-Dec	F	E	F	W,S	No	n.t.	G
Stylosanthes guianensis-Sc	F	D	F	Je-Dec	P	G	P	W,S	No	n.t.	n.t.
Stylosanthes guianensis-E	F	D	F	Je-Dec	P	G	P	W,S	No	n.t.	n.t.
Leucaena leucocephala-A	E	D	E	12 mos.	E	E	F	W,M,R,S	Yes	G	P
Leucaena leucocephala-A	E	D	E	12 mos.	E	E	F	W,M,R,S	Yes	G	P
Leucaena leucocephala-P	E	D	E	12 mos.	E	E	F	W,M,R,S	Yes	G	P
Leucaena leucocephala-Pe	G	D	E	12 mos.	G	E	F	W,M,R,S	Yes	G	P
Leucaena leucocephala-Cu	G	D	E	12 mos.	G	E	F	W,M,R,S	Yes	G	P
Aeschynomene histrix	G	D	F	Je-Mar	G	E	E	W	Yes,L	n.t.	E

Table 1b. Growth and production characteristics of introduced tropical legumes (continued)

ILCA's additional accessions, 1983-85 plantings	DM yield	Flower-ing	Seed prod.	Green-ness	Survival ability	Insect resis.	Weed resis.	Estab. Ease	Graze 1st yr.	As Inter-crop	Animal preference
Macrotyloma axillare	P	D	P	Je-Dec	P	P	P	W	No	n.t	n.t.
Macroptilium atropurpurcum	F	I	G	Je-Mar	F	G	G	W	Yes	n.t	G
Stylosanthes hamata-CIAT 147	G	D	G	Je-Mar	G	G	F	W,S	Yes,L	n.t.	n.t.
Stylosanthes macrocephala	G	D	E	Je-Dec	G	E	G	W	Yes	n.t.	n.t.
Stylosanthes capitata	F	D	F	Je-Dec	G	G	F	W,S	Yes,L	n.t.	n.t.
Stylosanthes capica	G	D	F	Je-Dec	G	G	F	W,S	Yes,L	n.t.	n.t.
Centrosema macrocarpum	P	I	F	Je-Dec	F	G	P	W	No	n.t.	n.t.
Centrosema pubescens	P	I	F	Je-Dec	F	G	P	W	No	n.t.	n.t.
Centrosema brasiliensis	G	I	E	Je-Mar	G	G	G	W	Yes	n.t.	n.t.
Dolichos lablab	E	D	F	Ju-Jan	P	G	G	W,M	Yes	E	n.t.

Table 2. Key to Tables 1a and 1b.

A. Dry Matter Yield Codes

E = Excellent G = Good F = Fair P = Poor

B. Variety or Cultivar:

L = Local
A = Australia
Sc = Schofield
E = Endeavor
P = Philippines
PE = Peru
Cu = Cunningham

C. Other Abbreivations:

DM = dry matter
I = indeterminate
D = determinate
n.t. = not tested
W = needs weeding
M = needs adequate moisture
R = better if inoculated
S = better if scarified
L = lightly

Grasses

In the first years of the forage program, emphasis was placed on legume introductions with very little focus on adapted grasses. It was assumed that in The Gambia, as in most of the tropical world, protein was a major limiting factor in livestock diets. Also, forage legumes seemed to be a crop that would fit into the local cropping systems, whether as fallow or intercrops, while grasses were more suitable to extensive (i.e., range) systems. This focus on legumes has continued with only slight attention given to grasses. One local grass, Andropogon gayanus has shown several favorable characteristics that warrant its promotion. It is very productive, it can be grazed the first year after planting and it maintains its production well into the dry season, often re-sprouting after cutting, burning or grazing despite lack of moisture. It can either be seeded or root transplanted, the latter producing a thicker stand the first year. Andropogon (gamba grass) is fairly low in protein (2 - 7% CP) and does best when combined with some other feed, especially groundnut hay. The impor-

tant point is that gamba grass is highly productive and is there when other feed sources have senesced or disappeared.

Panicum maximum is another grass that has been studied but not extensively field-tested. It, too, is highly productive of biomass but does not do as well in the dry season as does gamba grass. Range specialists with the project have done most of the work on both of these grasses as well as buffel grass, Cenchrus ciliaris, for use in deferred range areas.

Seed multiplication

A seed program capable of providing farmers with good quality seed is essential to a nation's agricultural development (Douglas, 1980). Importing seed may be the quickest way to make good seed widely available but when the seed is being imported from the far corners of the globe, such seed becomes prohibitively expensive. Prior to 1985, seed had been collected from experimental plots but not enough was produced to use for on-farm trials. In 1985 seed multiplication of tropical legumes on a small scale at Sapu. Production was hampered by lack of equipment and limited knowledge about tropical legume seed production. Short-term visits to Texas and Florida by Ceesay and to Ethiopia by Russo to learn about small-scale appropriate seed production methodologies were useful but not enough. The Seed Multiplication Unit (SMU) at Sapu is only prepared to handle cereal grains. Seeds of tropical legumes are very small and often irregularly shaped. Stylosanthes, for example, has seeds with small hooked awns which are difficult to clean. All of the tropical legume seed production thus far has required a great deal of hand labor and only small quantities of seed have been realized. Nevertheless, given time and additional training of staff, it will be possible to produce enough seed to start conducting on-farm trials.

Figure 1. Stylosanthes scabra, Yundum

Figure 2. Leucaena leucocephala, Yundum

Experimental Trials

Intercropping Trials

Fitting a forage legume into traditional cropping systems is a fine art. It has to be done without seriously reducing food grain yields in the same year, even though it may raise them in subsequent years, and without adding intolerably to farmers' labor requirements during the busy cropping season.

One technique that appears to work well and doesn't disrupt traditional practices is undersowing (Chater, 1985). Farmers sow the legume with or after the main food crop which is then harvested first, leaving the legume more room to continue growing. Optimum sowing times vary for different varieties.

Another technique that could work if farmers were to accept the principle of fodder banks is to superimpose the growing of cereals into areas already sown to legumes. When legumes are planted in pure stands, the more vigorous their growth, the less likely it is to be sustained (Chater, 1985). The extra nitrogen added to the soil makes grasses and weeds flourish, choking the legume after a few years. The suppression of legumes by grasses and weeds in the introduction trials and fodder banks planted around the country in 1983 are evidence of this phenomena. Introducing a cereal crop into the fodder bank is merely an extension of the rationale for fallowing except that a forage legume should add more nitrogen to the soil than a native fallow.

A third technique used successfully in many areas of the world is alley cropping of leguminous shrubs with cereal crops. The legume is planted in wide rows and the cereal(s) are planted in several rows between the legume. The legume stays in place for several years, providing grazing or fresh forage for cutting, nitrogen for the cereal crop and eventually providing firewood.

Several intercropping experiments have been conducted during the past three years. These were indeed "experimental" as the forage agronomists, with some assistance from the maize agronomists, tested the intercropping techniques as described above in the search for methods that would work in The Gambia. Many of the experiments have shown what will not work and where problems can occur. A summary of what has been learned follows.

Several intercropping experiments were conducted in 1984 and 1985. In one experiment in 1984, maize was intercropped with two varieties of pigeon peas Cajanus cajan. The pigeon peas were cut at periodic intervals well into the dry season. One of the pigeon pea varieties (from University of Florida) survived the severe cutting regime and produced seed in 1985 and 1986. During the 1985 dry season two maize-cowpea experiments were planter under irrigation. One was designed to test the differences between planting cowpeas within the rows of maize or between the rows of maize at

either the first or second weeding. Figure 3 shows cowpeas planted between the rows of maize at the first weeding. The second experiment used the same planting arrangements and either one or two cowpea seeds per hole. Serious fuel constraints led to a very erratic irrigation schedule and severe moisture tension gradients in the plots. Hence no quantitative data were collected. However, it was observed that the cowpeas provided excellent ground cover and weed suppression especially when planted between the rows and that maize growth was vigorous.

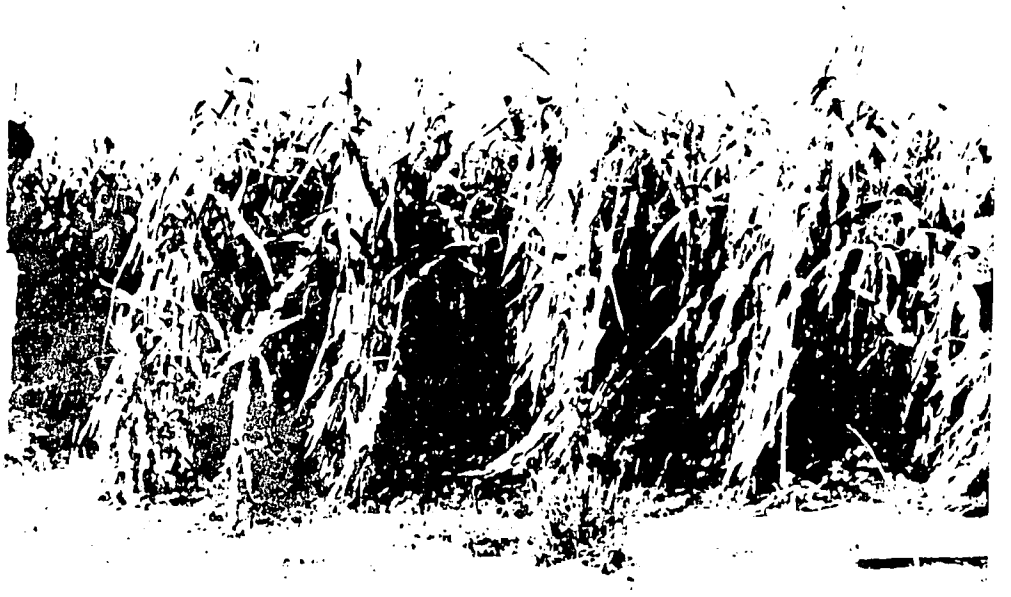

Figure 3. Maize-cowpea intercropping trial, Yundum

A joint experiment by the maize and forage agronomists was attempted at Sapu in 1984. Half of a large area had been sown to Stylosanthes species in 1983 while the other half remained in bush fallow. Small strips were cleared in these legume and bush fallows and were planted with maize. The strips cleared were too narrow and were quickly covered with regrowth so that the maize could not grow. Further work along these lines should make certain to clear wide enough strips for the cereal crop.

Other collaborative work on intercropping with the maize agronomists is described in that unit's report. This includes experiments conducted by M. Norem in 1985 on maize-cowpea intercrops.

In 1985 an experiment was conducted on maize undersown with three Stylosanthes varieties: hamata, humilis and capitata at Yundum, Sapu and YBK. Parameters measured were plant height, density and maize yield. There were significant differences between Stylos in terms of height with S. capitata performing the worst. There were no differences in plant density across locations. Maize grain yield was uniformly poor at all sites, not only in this experiment, but in all intercropping experiments using maize in 1985, probably because of poor seed.

Several intercropping experiments have been attempted with Leucaena. In 1984, a maize-Leucaena experiment was designed to test three varieties of Leucaena in an intercropping arrangement. Despite scarification, inoculation and two plantings, the Leucaena could not compete with the maize or weeds. It was decided that the Leucaena would have a better chance of survival if started in plastic bags before planting season and planted as seedlings. This was done during the 1985 dry season so that an alley cropping experiment using Leucaena, Sesbania and Gliricidia could be planted using seeds of the latter two legumes and seedlings of the Leucaena. The legumes were planted at 4m intervals with three rows of maize between the legume rows. A caterpillar Amsacta spp. attack wiped out all of the small seedlings in this (and other experiments) leaving only the Leucaena unscathed.

Again in 1985 a maize-Leucaena intercropping experiment was planned using already established Leucaena plots 2-3 years old at Yundum, Sapu and YBK. The Leucaena was in one meter rows, cut off at one meter heights and had one row of maize planted between the rows of Leucaena. The maize could not compete with the Leucaena which re-grew rapidly. Consequently grain yield was minimal.

Despite the lack of quantified data from these legume-cereal intercropping experiments, several conclusion may be drawn. These are:

1. Leucaena must be started 2-3 months before the rainy season in order to be strong enough to compete for moisture and light.

2. In an intercropping situation, well-established stands of Leucaena must be cut more than once during the growing season so that the cereal crop will receive adequate sunlight. Leucaena regrowth is so rapid that at least two meters must be left between the rows for cereal crops.

3. Sowing a cereal into a legume fallow will work only if a large enough area is kept clear around the cereal to enable it to grow. No-till techniques advocate the use of herbicides but in The Gambia a more appropriate method is just to make the strip fairly wide and to weed it as it would be normally weeded.

4. Undersowing Stylosanthes into maize has potential and should be explored. Time of planting the legume into the cereal crop (at

first or second weeding, for example), rate of seeding and row widths are refinements that need to be researched.

5. Cowpeas are an excellent crop with cereals, providing soil cover and weed control, but are extremely susceptible to insect attack. Variety trials using several cowpea varieties as an intercrop should be conducted.

6. Several leguminous shrubs - Leucaena and pigeon peas in particular - work well in alley cropping situations. Actual production levels of fodder and grain need to be determined.

Clipping trials

In addition to the introduction plots of tropical legumes and grasses which tested the adaptability of these plants to Gambian conditions, a study of the effects of clipping at different intervals on the legumes was conducted. Plots were subjected to clipping at either four week or six week intervals from August to December at Yundum, Sapu and YBK in the 1985 season. As expected, there were wide differences between legumes in dry matter production with Stylosanthes hamata being the most productive followed by S. hamata, S. guianensis and Leucaena. Interestingly enough, for some cultivars there was no difference in production when cut either at four weeks or at six weeks (S. capitata and an S. hamata cultivar from Australia for example) while for other legumes, the six week clipping produced less forage than the four week clipping (an S. scabra cultivar from CIAT). Usually, though, the longer interval produced the best yields, often more than doubling the amount of dry matter produced. In practical terms, this means that some of these forages could be used for grazing from August through December for short periods without reducing productivity for dry season grazing. If planted near a village, for example, the legumes could be used to feed draft animals during their major work season and then used for grazing late in the dry season for other livestock.

Crop Residue Feeding Trials

Inadequate nutrition is perhaps the single most important constraint to livestock productivity in the tropics. In The Gambia, the problem of inadequate feed supplies is exacerbated by several factors including the eight-month dry season, a decrease in natural and permanent grasslands, an increase in both the livestock and human population, the unavailability of improved pasture seed and the dearth of research on animal nutrition in the country. Research on the use of crop residues for dry season feed has been one of the major efforts of the Mixed Farming Project forage agronomists. Feeding trials were conducted from 1982-1985 to evaluate locally available crop residues.

The use of crop residues for livestock feed in The Gambia is not new. For many years farmers have been allowing livestock to graze the crop fields after harvest and have been saving some of their groundnut hay to be fed to draft animals and small ruminants. Crop residues are in fact used worldwide, in both developed and developing countries, for many purposes of which livestock feed is but one.

What is new for The Gambia are the feeding trials run from 1982-1985 with the specific intent of determining the nutritive value of crop residues produced in The Gambia and to initiate an animal nutrition program to test those residues with N'dama cattle. Feeding trials had been conducted in the early 1970s but data from these trials are elusive (see Dunsmore et al., 1976). These trials are a step toward developing a year round livestock feeding program for Gambian farmers and documenting the results for future research.

The importance of crop residues as compared to natural grazing clearly depends on the ecosystem involved and the pressure for land from the human population. Desertification in the Sahelian countries and a population growth rate throughout much of Africa of over 3.5% are two factors which influence the availability of land, both for crop production and livestock use. In The Gambia, the amount of land put into arable crops increases every year as the human population increases. Livestock can no longer rely solely on native pasture and bushlands for their feed supply as they are prevented by crop production both from grazing and from moving freely in search of browse. While livestock owners are beginning to show an interest in improved pastures, or at least in some of the improved species, it will undoubtedly be a long time before they become an important component in Gambian farming systems. Hence, the continued interest in finding alternative sources of feed.

An understanding of the animal feeding system is needed in the framework of the farmer's total farming system of which livestock production is only one aspect. A small farmer's livestock production goals are usually survival of the animals during the dry season rather than maximum animal performance. In addition, generally little cash expenditure is made on the animal production enterprise (Kiflewahid et al., 1983). Technical solutions must be appropriate for these systems and alternatives should be evaluated by measuring the costs and benefits incurred. Many crop residues are thought of as "free" because there is no apparent market price for them or because the farmer's labor costs for collecting them are not considered. For the most part, these feeding trials did not take into consideration economic costs and benefits but were instead concerned with defining parameters of animal production. That is not to say that such studies should not be included in the future.

Where there is no limitation to grazing lands, the use of crop residues for supplemental feed becomes less important. In very populated areas with little or no access to grazing by animals, crop residues may be the only feed available. The Gambia lies somewhere between these two situations. Whether or not feeding of crop residues becomes economically

attractive depends upon the farmers' goals with respect to slaughter cattle and the decreasing availability of land. For the time being, if the farmers' goals are accepted to be survival of their cattle with minimal cash input, then research on the technical aspects of crop residue feeding should continue in order to assist farmers in meeting these goals.

All of the feeding trials were conducted at the Farmyard, Yundum, using heifers from the research herd of the Department of Animal Health and Production. Animals were placed five per pen on a random basis, fed daily, supplemented with mineral salt and 0.5 kg groundnut dust/head/day, provided with water and weighed regularly. The amount of feed on offer was weighed daily as was the feed left from the previous day in order to determine actual average daily intake. The animals used were 2-3 year old N'dama heifers weighing between 100-200 kg. An attempt was made in the 1985 trials to use as many of the heifers that had participated in the 1984 trials as possible. Two trials were conducted in 1984 (Trials 84-1 and 84-2) and three in 1985 (Trials 85-1, 85-2 and 85-3). Details of these trials and earlier ones can be found in the report by Russo on the crop residue feeding trials (Russo, 1986).

Trial 84-1, with 20 two-year old heifers (5 per treatment), used maize stover, sorghum stover, gamba grass hay and groundnut hay. The first three feeds were chopped with a manually operated chopper to increase intake. All of the animals gained weight with the groundnut hay treatment providing the highest gain (+19 kg). Average daily intakes were higher (4.98 kg) for groundnut hay as compared with the other feeds, maize stover being the lowest at 2.31 kg ADI.

The same heifers were used for Trial 84-2 in which they were fed one of two rations replicated twice: either groundnut hay and gamba grass or groundnut hay and sorghum stover. In this trial, all of the animals showed weight losses the last week of the trial and only one replicate of the groundnut hay-gamba grass ration produced an overall weight gain of 5 kg for the course of the trial. Intakes were fairly uniform throughout the test period. From the beginning of Trial 84-1 to the end of Trial 84-2, 16 out of 20 animals gained or maintained their weight, 3 animals lost 5 kg or less and one animal lost 17 kg.

Due to management problems at the Farmyard, in 1985 all feed was stored at the field site and all feed and refusal weighings were done there. Trial 85-1 combined stovers and legume hays on a 1:1 basis. The feeds were maize stover or sorghum stover and groundnut hay or Stylosanthes hay. Twenty, three year old heifers were used. Average daily intake was equal for all feeds. Sorghum stover and either of the legume hays gave the best gains while animals on maize stover and legume hay only maintained or even lost weight.

In Trial 85-2, Trial 84-2 was repeated in order to replicate the experiment over time. Intake of the ration of sorghum stover and groundnut hay was higher than of the gamba grass-groundnut hay ration. Weight gains and losses were minimal.

In The Gambia there are several agroindustrial by-products available in certain areas that make excellent livestock feed. These by-products are groundnut cake and groundnut dust (Banjul), citrus pulp and peels (Yundum), rice bran (Kaur) and cotton seeds and pods (Basse). The purpose of Trial 85-3 was to determine the feeding value of groundnut cake. Two treatments, replicated twice, were used: gamba grass or sorghum stover fed ad libitum with 5 kg groundnut cake per head. In 3 of the 4 treatments, the heifers gained weight with an overall average daily gain of 238 g/head. From January through May (Trials 85-1, 2 and 3) heifers lost an average of 3.75 kg. Some individual losses were higher (-20 kg) as were gains (+10 kg).

On all of the crop residues, with the exception of maize grain and groundnut cake which are high in both energy and protein, animal weights were usually maintained with the likelihood of weight gains increasing with the amount of groundnut hay in the ration. This is to be expected because groundnut hay is high in both protein and energy. A limited number of the feeds used in these trials have been analyzed for their nutritive value. Facilities for forage analyses are limited in The Gambia both by out-moded equipment and lack of reagents. The inability to determine the quality of feedstuffs makes it difficult to interpret results of the feeding trials. Often, the nutritive value of feed is only a "best guess" estimate. Analyses have been done of a few selected feedstuffs (see Tables 3 and 4). All of the crop residues used, with the exception of groundnut hay, are quite low in crude protein content. Mixing the various residues with groundnut hay appears to be an excellent way to increase crude protein content of rations. Groundnut cake is very high in protein but is only available in the Banjul area. Groundnut dust, interestingly enough, is no better than groundnut hay as a protein source.

Table 3. Analyses of Crop Residues Used in Trials 85-1, 85-2, 85-3.

Feedstuff	DM	Ash	Protein	Ether Extract	NDF	ADF	Cellulose	Lignin
Gamba grass	95.5	4.4	1.8	n.a.	78.7	45.7	39.2	6.5
Groundnut hay	94.8	8.5	11.6	n.a.	47.5	36.7	26.3	10.4
Maize Stover	97.5	41.4	2.9	n.a.	49.2	29.7	22.8	0.9
Sorghum stover	96.2	10.6	3.1	n.a.	71.7	45.2	35.4	16.8
Stylo hay	95.9	10.2	4.2	n.a.	73.6	57.3	40.5	2.9
Groundnut cake	95.3	4.3	52.2	5.6	20.4	13.4	10.5	2.9
Groundnut dust	95.8	16.9	11.5	4.3	55.8	44.6	29.5	15.1

n.a not available
Analyses done at University of Sweden, Uppsala

Table 4. Crude Protein Analyses of Feed and Orts for Trial 85-1

Feedstuff	MS/GH	SS/GH	MS/SH	SS/SH
Feed	13.4	11.9	10.6	10.4
Orts	11.0	10.3	10.6	11.1

MS/GH - Maize stover and groundnut hay
SS/GH - Sorghum stover and groundnut hay
MS/SH - Maize stover and Stylosanthes hay
SS/SH - Sorghum stover and Stylosanthes hay

The neutral detergent fiber analyses (NDF, ADF, cellulose and lignin) indicate that gamba grass hay, sorghum stover and Stylosanthes hay are fairly low quality feeds because they are high in poorly digestible fiber. This is coupled with low protein values for these feeds. The two legume hays are very high in lignin which is also usually associated with poor digestibility although legumes do tend to be higher in lignin when compared with grasses as a general rule.

It should be stressed that the figures presented here are one time estimates of the feed quality of some crop residues. Data on fertilization of the crop, harvest and storage methods and date of sampling are essentially not available yet all of these factors have a significant effect on feed quality. Nevertheless, it is possible to visualize what would be required of the locally available feedstuffs to produce a reasonably balanced ration for cattle.

Crop residues and stovers are generally regarded in developed economies as low quality feedstuffs, usually requiring supplementation if animal weights and condition are to be maintained. Two points need to be considered. The first is that free-ranging ruminants normally have a choice of diet and when presented with stover will initially select the most palatable portions of the total plant, usually leaves, as they would do when grazing in the bush. Work done by Powell in Nigeria (1985) showed there were significant differences between the nutritive value of plant parts of sorghum, millet, maize and groundnuts. In maize plants the stalks were the most digestible part of the plant, being lower in lignin, NDF and ADF. Sorghum and millet leaves were the most digestible portions of those plants while all parts of groundnuts, including stems and roots, were highly digestible. Cereal crop residues would be of highest value just at harvest when the plants are still green and leafy, a factor which should be remembered in farmer training and extension visits.

Yet the second point is perhaps more important at this stage of stover feeding in The Gambia (as well as in other parts of sub-Saharan Africa) and that is that almost any crop residue has value as a dry season feed if only in that it prevents the drastic weight loss that usually occurs at that time of year. Even a low quality feed is used efficiently when an animal is under nutritional stress. The N'dama, a Bos indicus breed, belongs to a species that is especially known for its ability to efficiently utilize minimal feed resources. In 1985 when the rains were four weeks late, farmers participating in the village-level feeding trials were gratified to have some feed for their livestock whilst other animals went without and many starved. While research on crop residue feeding strategies continues, a big step toward convincing farmers of the value of crop residues was made as a result of those late rains.

One crop residue that has always been utilized, to a greater or lesser extent, is groundnut hay. There are several ways to produce the hay, giving a product that ranges from bright green leafy material to dry stems and roots. According to Powell (1985) even the stems and roots of groundnuts are of higher feed value than residues of other crops. Trial 82-1 showed no significant differences in weight gain or intake between tradi-

tionally made groundnut hay and improved, good quality groundnut hay (Hedrick and Bojang, 1983). By whatever means the hay is made, it is an excellent feedstuff. In the past it was kept primarily for draft animals and small ruminants or sold to Senegalese traders. Recently, however, farmers are saving as much as possible for their own livestock use. While hay may never be equal in monetary value to the nuts themselves, it is interesting to note that in the past three years a lorry-load of hay has gone from D30 to D150 and that groundnut hay is almost as difficult to obtain as fuel wood in urban areas.

Grazing Trials

The best measure of the productivity of grazed grassland is made in terms of animal performance. However, this is expensive and often not possible due to lack of controlled area or lack of animals. The evaluation of grasslands through animal production must generally involve compromises between the desirability of studying a total system on an adequate scale and the resources available (Morley, 1978).

There are several stages involved in the testing of new varieties or cultivars of pasture species. After small plot introduction trials and, if possible, before extensive studies with fertilizers, cutting regimes, moisture levels and the like, the pasture plants should be evaluated by animals. Early evaluation by animals prevents the promotion of species with undesirable characteristics for particular systems. For example, a pasture species may be unable to withstand even moderate amounts of grazing and would therefore only be useful in a system employing rotational grazing and frequent rest periods for that particular species. Depending on the information being sought, the inclusion of animals early on in the forage testing procedure need not be prohibitively expensive if the trials are kept simple and small.

There are two approaches to the study of pastures and their utilization by grazing animals. The first is concerned with the pastures, the other where the main interest is with the animal. Determining the relative palatability or acceptability of a range of pasture species would be an example of the first case. In the second case, normal measures of animal performance, e.g., weight gain, milk production, etc., necessitate longer term trials in order to evaluate the effect of the pasture species on animal production.

As a second step (after introduction trials) in the forage testing program, several pasture legume species were subjected to intermittent grazing to determine their relative palatability. Animal preference was measured by time spent per individual plot of a species. Plots of legumes were established at Yundum, Sapu and YBK in 1982 and 1983 (see Table 5). The entire areas were fenced but not individual plots. In February 1984 the trials were started using work oxen because they were readily available

and deemed to be more tractable than other cattle. Two oxen were used at each site with two observers recording movement, time spent grazing per plot and number of bites per minute for two consecutive days. Due to staff changes and the advent of the planting season, it was not possible to continue the grazing studies until August that year, at which time sheep and goats were added to the trials. The trials continued every month through December.

Several factors relating to animal behavior became immediately apparent. The oxen came into the study area in the early morning, walked around sampling the plants and settled onto one or two species. On the second day they immediately went to the species they had chosen the day before without doing any further testing usually. Each day after grazing non-stop for anywhere between two and three hours they would stop grazing, lie down, ruminate and usually not graze for the rest of the day.

The small ruminants were not nearly so compliant and, in fact, were very unsatisfactory as study animals. The sheep essentially refused to eat the legumes and concentrated on the grassy weeds or stood against the fence and ate the herbs on the other side. The goats were primarily concerned with escape and had to be forcibly prevented from doing so. If staked into a particular plot, the goats would eventually graze that species but such grazing would not be a true test of the plant's palatability. The only exception to the goats' behavior occurred when small, young seedlings of Leucaena were present which the goats relished, stripping the seedlings bare of leaves. The sheep would rarely graze any of the legumes unless staked in one area. The behavior described for the small ruminants was consistent across locations and for both sexes.

Table 5. Legumes studied in grazing trials

Species	Location Yundum	Sapu	YBK
Leucaena leucocephala-Cunningham	X	X	
Leucaena leucocephala-Australia	X	X	X
Leucaena leucocephala-Philippines	X	X	
Leucaena leucocephala-local	X	X	X
Stylosanthes guianensis	X	X	X
Stylosanthes scabra	X	X	X
Stylosanthes hamata-Australia	X	X	X
Stylosanthes hamata-local	X	X	X
Stylosanthes hamata-CIAT			X
Stylosanthes humilis-local	X	X	X
Aeschynomone histrix		X	
Macroptilium atropurpurcum	X	X	

Indicated in Table 6 are the legumes preferred by oxen and in Table 7, those preferred by sheep and goats on a monthly basis. It immediately becomes apparent that the Stylosanthes hamata and humilis cultivars are the most palatable to the oxen and to a lesser extent to the sheep. Even when very dry (in February) S. hamata and humilis were preferred over greener plants, i.e., Leucaena and S. scabra. Total time spent grazing by the oxen never exceeded three hours per day. Almost all of the legumes would be sampled by the oxen but were grazed for only 2-3 minutes; preferred species would be grazed for at least half an hour per day.

Changes in vegetative growth are not as well indicated in these tables. As mentioned above, only Leucaena and S. scabra were green in the dry season. Macroptilium atropurpureum (Siratro), a twining vine, has slow growth during the rains but produces a great number of leaves just after the rains. S.guianensis at Sapu is extremely vigorous yet very unproductive at the other two sites. In February, Aeschyomone histrix plants at Sapu were small, low-lying and, widely-spaced and were relished by the oxen; after the rains the A. histrix plot was completely filled in, was tall (>1 m) and the oxen would not graze it.

How can the results of the grazing studies be applied to future work and to Gambian livestock systems? Preferred species of legumes have been identified; serendiptously these legumes are also well adapted to The Gambia. Yet it is just as useful to know which species were not preferred. Stylosanthes scabra, for example, is very productive of dry matter but extremely hairy, with woody stems, hence not palatable. It could be planted in an unfenced deferred range area with its unpalatability keeping it from being grazed until many other species were gone, providing a kind of rotation without fencing. While the case against Leucaena seems clear, i.e., hardly ever grazed by livestock during the trials, only a few months later, when the pasture plots were grazed off, the cattle went first to the Leucaena and consumed most of the plants. More work is needed on Leucaena to sort out this anomaly. As a further note of interest, S. hamata seeded itself into the Leucaena plots. The geometry of these two legumes is well-matched, the Stylo being fairly short and bushy and the Leucaena very tall. The oxen preferred grazing in these plots (see Figure 4).

Figure 4. Leucaena and Stylosanthes hamata grazed plot.

Table 6. Order of preference, as measured by time spent grazing, of legumes by oxen.

Months, 1984	Locations		
	Yundum(a)	Sapu	YBK
February	S. hamata-Aust. S. hamata-local	A. histrix S. hamata-local	S. hamata-local Leucaena-local S. guianensis S. humilis
August	S. humilis S. hamata-local S. hamata-Aust.	S. hamata-local S. hamata-Aust.	S. humilis S.hamata-Aust. S. hamata-local
September		S. hamata-Aust. S. hamata-Aust.	S. humilis S. hamata-Aust. S. scabra
October	S. humilis S. hamata-local S. hamata-Aust.	S. hamata-Aust	S. hamata-CIAT S. humilis
November	S. humilis S. hamata-Aust. S. hamata-local M. atropurpurcum	S. guianensis S. hamata-local M. atropurpurcum	S. hamata-local S. humilis S. hamata-Aust
December	S. hamata-Aust. S. humilis S. hamata-local	S. guianensis S. hamata-local M. atropurpurcum	S. hamata-CIAT S. hamata-Aust.

(a) Grazed more than 10 minutes

Table 7. Order of preference, as measured by time spent grazing, of legumes by small ruminants.

Months, 1984	Locations					
	Yundum(a)		Sapu		YBK	
	Sheep	Goats	Sheep	Goats	Sheep	Goats
August	(b)	(b)	(c)	(c)	S.humilis S.hamata-local	S.hamata-local
September	S. humilis	(c)	S.hamata-local	Leucaena-P(d)	S.hamata-local S.humilis	S.humilis
October	(b,c)	(c)	S.hamata-Aust.	Leucaena-P(d)	S.scabra	S.scabra
November	(c)	(c)	S.guianensis	Leucaena-P(d)	S.scabra S.humilis	(c)
December	S.humilis	(c)	(c)	Leucaena-P(d)	S.hamata-CIAT S.scabra	S.hamata-CIAT

(a) Grazed more than 10 minutes
(b) Ate weeds
(c) Did not graze or grazed less than 10 minutes
(d) Plot contained new seedlings

Village Feeding Programs

The village feeding program is a joint effort between the forage agronomists and range scientists in which animals are chosen from village herds (usually heifers), kept together in a fenced area and fed on crop residues, e.g., maize stovers, groundnut hay and rice straw, for a certain length of time during the dry season. This program started in the village of Boiram in the Fulladu West District in the 1984 dry season. Details of this program will be in the final report for the MFP range ecologist.

In 1984-85 the Livestock Owners Associations (LOA) of the villages of Sukuta, Piniai and Makamasseri joined the feeding program. At Sukuta a causeway for animals was made at the side of the river to enable the animals to drink water without drowning as had often happened in the past. In Sukuta the animals traveled about 3 km to the river, using the newly constructed causeway. Causeways were started but not completed at Sutokoba and Saraji Kunda. Fences were erected for range fields in 1984 in Sukuta, Piniai, Makasseri and Boiram. A scale was provided for the weighing of the animals Based on the previous year's experience, crop residue feeding was not started until March. Heifers were fed maize and sorghum stover for one month then sent to the range plots for one month, spending the last month in the fenced area eating groundnut hay and rice straw.

A field day was organized for the LOA in April at YBK and Giroba Kunda seed multiplication sites. Members from Niamina, Niani and Fulladu West were brought to YBK; members from Fulladu East, Kantora and Wuli were brought to Giroba Kunda. They were shown the methods and practices for storage of crop residues, feeding techniques, and how to take care of their range and pasture fields before allowing animals into them. They were also advised on when to burn so as to have green feed at the beginning of the dry season when other feeds are dying off. At this meeting most of the members expressed appreciation of the program. They asked to have programs in their individual villages as some are far from the currently participating villages.

The village feeding program has been expanded to even more villages for the 1986 dry season. For this season, the task of organization has been left almost entirely up to the Pasture Assistants and farmers themselves to see whether the programs will continue without a lot of MFP supervision.

One of the most encouraging aspects of this program is that some villages in URD without fencing have made their own platforms and are keeping their stovers for their animals. Groundnut hay has always been fed to their draft animals and the surplus sold to other farmers, often across the border. Now almost all of the groundnut hay is being preserved for livestock feeding. A survey conducted in late December 1985 showed that in villages surrounding the participating villages a major effort was being made to save crop residues without any input from MFP. This is an excellent example of farmer-to-farmer information exchange.

One of the main problems encountered is getting maize stover stored properly since this has to be done after the rains while maize grain is usually harvested before the end of the rains. It is also a busy time of the year when there is much field work going on. Farmers have been asked to shock their stovers in the field until the rains are completed before stacking them nearer to the village to avoid molding of the residues. Related to this is the safekeeping of the stovers, e.g., in a fenced area or by building a platform high enough to keep animals from reaching it.

Another problem is watering of the animals. At the end of the dry season the wells in many villages are almost dry and there is competition between the animals and humans for water. In some cases animals may have to travel 10-12 km to the river every day to drink. Solutions to the water problem in villages are not in the realm of the Mixed Farming Project to solve; farmers must find the solutions themselves.

The third problem is burning of the bush. Although against the law, farmers, themselves, must see that the law is enforced and that anyone caught will be punished. In the North Bank farmers are especially careful not to set fires and some villages of URD actually have guards looking out for firesetters and fires.

This year farmers in URD have stated that they will continue the program even when the Mixed Farming Project ends. We think this is true since some of the farmers have started keeping their own stovers, either on platforms or in self-made fences at the back of their compounds.

The Extensions Agent's role is to see that correct sizes of animals are selected for the feeding program, that the right amount of feed per animal per day is given and at the right time, i.e., when there is scarcity of feed for the animals. The farmers' role is to feed the animals in the dry season, being sure to water them every day. The Area Council or Government could provide drinking troughs for the animals near the wells. Government, Area Councils and donor agencies need to solve water/well problems on a case-by-case basis taking into consideration human and livestock pressure as well as environmental constraints.

Herding Study

In June 1984 a collaborative study with the MFP socio-economists was initiated. The purpose was to collect information on cattle herds in four regions of the country. The herds were from the villages of Jakoi (Western Division), Piniai and Sukuta (McCarthy Island Division) and Gambissara Lamoi (Upper River Division). Among the data collected were ownership, herd composition, births, deaths, sales, milk production, distance traveled per day and types of areas grazed. In November a training course was held for the enumerators to teach them rudimentary plant identification. After

the course, and until the end of the study in May 1985, samples of plants most commonly grazed were collected for identification and analyses.

All of the herds were managed by Fula contract herders who are paid D1 per head per season plus half of the milk produced. Owners pool their animals into herds in June at the start of the cropping season. The herder is expected to keep the animals away from the cropped areas until after the harvest. Usually in December the herders cease their employment and the cattle are allowed to graze where they wish and to go to water on their own.

Table 8 indicates the distance traveled per day by each of the herds while grazing and going for water. The Piniai and Lamoi herds did not travel far because the water source is close to those villages. In Sukuta, the animals were herded away from the village and the river in the morning, doubling back to head for water in the evenings. Once planting started in Jakoi the herd was kept away from the village, in the forest, and consequently walked further than during the dry season.

No pattern of grazing could be observed from the data collected except that cattle were kept away from the cropped areas during the rainy season. Each herd behaved differently, probably for many reasons: source of water, vegetation in that area, herder preference, etc. Sukuta, for example, is surrounded by lowland swamp and rice fields while Jakoi is surrounded by forest. The plant samples collected indicated that most of the forage grazed over the year (excepting the crop residues left in the fields) were grasses (see Table 9). Very few native legumes are present in the bush that cattle would eat. Some of the plant samples have been sent to ILCA, Addis Ababa, Ethiopia, for nutrient analysis. Those results are not available yet.

Table 8. Kilometers traveled per day by four herds during 1984-85

	Jakoi		Piniai		Sukuta		G.Lamoi	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Jun '84	5.8	1.6	N.A.		N.A.		1.6	0.3
Jul	12.2	0.6	2.2	0.1	17.6	1.6	2.1	0.0
Aug	9.6	0.3	1.4	0.1	14.5	1.6	2.3	0.1
Sept	9.2	0.4	1.8	0.1	15.9	0.7	2.8	0.2
Oct	10.1	0.4	1.7	0.1	16.4	0.8	3.0	0.1
Nov	9.2	1.1	1.4	0.1	14.6	1.2	2.9	0.4
Dec	9.0	0.4	1.6	0.1	14.6	0.6	3.2	0.0
Jan '85	5.8	1.0	1.3	0.1	12.6	0.5	2.5	0.0
Feb	7.1	0.5	1.6	0.1	12.7	0.6	2.4	0.2
Mar	7.1	0.5	1.8	0.2	13.5	0.3	3.8	0.1
Apr	5.9	0.3	2.0	0.0	14.9	0.6	3.9	0.1
May	5.7	0.3	2.1	0.0	17.1	0.7	4.2	0.2

The rationale behind the study, vis a vis, the forage agronomy program, was to try to understand what cattle are eating over the course of the year. The feed resources of the crop residues, even when poorly managed (i.e., left in the fields after harvest and not stored or stacked) provide a significant portion of the diet. Rice stubble in rice-growing areas provides three months of grazing, for example. Saving of the residues and different timing of the cropland grazing could lead to better utilization of those feed resources.

Table 9. The twelve most frequently grazed forages by cattle in four locations during the dry season (December-May).

Genus	Classification
Andropogon	grass
Pennisetum	grass
Pterocarpus	tree
Borreria	forb
Impoema	forb
Eragrostis	grass
Dichrostachys	shrub
Indigofera	legume
Cyperus	sedge
Alysicarpus	legume
Paspalum	grass

Forage Testing Facilities

While not specifically stated as a goal in the project document, some monies and effort have been spent in establishing a rudimentary forage testing laboratory. A Wiley mill (for grinding samples), a drying oven, a blower for the Kjeldahl unit, an atomic absorption spectrophotometer and various chemicals were purchased and located at the soils lab, Yundum. The Gambian sent to the U.S. for training in forage analysis and animal nutrition returned toward the end of the project when monies were running short for the purchase of additional supplies. Consequently, less than 500 samples have been analyzed for dry matter and crude protein. Clearly, any serious research program in forage agronomy must be supported by a forage testing lab. And such a lab will need recurrent budget support for reagents, other chemicals and supplies.

Reflections and Recommendations

Answers to the question, "How can livestock production be improved in The Gambia?" depend upon the group to which the question is addressed. Farmers will cite water and feed as the major constraints while veterinarians will cite animal health problems that limit productivity. Agricultural economists may ascertain that the marketing infrastructure needs improvement; sociologists may feel that changes in the land tenure system and in customs that relate status to number of cattle owned are needed to improve livestock production. Since this is the final report of the MFP Farming Project forage agronomist, we wish to emphasize our belief that in The Gambia, scarce feed resources during the dry season are probably the single most limiting factor for livestock production. An adequate feed supply must be in place before other programs such as digging boreholes or prophylaxis are instituted.

The next question then becomes, "How can the feed supply be increased?" This report has indicated the areas where research has been done. Some of these activities should be continued, some abandoned or postponed. Undoubtedly, there are areas of research that should have been explored but were not because of time or labor constraints or sheer oversight.

The developed countries of the world have a much longer history of research in agriculture than do most of the developing countries. Australia is perhaps the country whose research may be most applicable to African conditions. A recent paper by Jones (1983) outlines Australian research on the nutrition of grazing animals and discusses the relevance of those research findings to Africa. In the paper he states that this research has been a costly exercise extending over a quarter of a century and that even after this long period of research, the successful forage legume species number less than half a dozen. Our research in The Gambia has been for only five years and we have perhaps found as many suitable legumes.

At a CID Presidents Symposium (1985) various speakers went into some detail on the failure, or lack of success, of livestock projects in Africa. Some of those points are worth reiterating here as they relate rather poignantly to the experiences of the forage program. Several of the authors, for example, stressed that projects must be for a much longer term (note the quarter of century of Australian research). Five years is just a beginning for forage research here. We need to know not only how the biological components of the system respond to drought cycles, but how the cultural system has adapted to the cycles (Dwyer, 1985). Insofar as the forage testing aspect of the program goes, we have just begun to understand how the introduced species can be produced on the research station and what is needed to produce them under local conditions. What we do not know is how to fit these forages into the cultural system. Such a fitting could well take longer than the biological testing. As an example of a cultural constraint encountered during the biological testing, in one village we were allocated a piece of land for three years to test legumes with the

idea of establishing a fodder bank. Not only were animals allowed into the area to graze before the end of the three year period, in the second year the farmer was clearing and planting cereals into the area. He incidentally had an excellent crop of maize from that field. Clearly a communication problem existed in which the farmer did not understand the purpose of the test area and the agronomists did not understand the pressures for both livestock feed and arable land in that village. To improve forage and livestock production is only partially a matter of dealing with the problems and potentials of the forage-animal systems. One must also deal with the life situation of people (Massey, 1985).

What has been learned about forage production during the project's lifetime? Several legumes have shown excellent potential and could be fitted into Gambian farming systems given ample extension support. These are Stylosanthes hamata, humilis, guianensis, capitata and scabra, Leucaena leucocephala, Vigna unguiculata and Cajanus cajan. Additionally, the grass, Andropogon gayanus, is extremely well-adapted and highly productive throughout the year.

Specifically, the Stylos appear to be best suited to either intercrops with cereal crops (undersown after the first or second weeding) or to improve rangelands. Leucaena and pigeon peas are probably best utilized as alley crops or fence row crops because they need to remain in the soil for several years in order to realize their maximum production potential every year. Cowpeas are an excellent intercrop with maize or other cereals, providing ground cover, preserving moisture, suppressing weeds and producing both a grain and forage crop. Finding an insect resistant variety remains a major task. Seed production remains as the most serious constraint in the forage program. The second serious deficiency is lack of a good forage testing facility.

In The Gambia the pasture resources are being well utilized but too often, over utilized. Cattle populations increase every year. Stocking rates, therefore, increase. If stocking rates cannot be controlled then some form of pasture improvement must be introduced. A suitable starting point could be with legumes in a mixed farming system. Here the benefits to the following grain crops and to animals utilizing both crop residues and the legumes could provide the necessary stimulus for a closer integration of crops and livestock. Jones (1983) suggests that an appreciation of the contribution of grazing legumes to livestock production in a mixed farming system could then be extended to an appreciation of their worth in the freely grazed pastoral areas. Massey (1985) states that many of the problems associated with livestock projects can be summed up as a failure to capture the herder. In The Gambia we must try to capture the livestock owners, who are also always farmers, and convince them that integration of crops and livestock can benefit both systems.

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Russo, S.L., 1986. The Use of Crop Residues for Animal Feed in The Gambia. Technical Report No. 11. Mixed Farming Project, Banjul.

Appendix A: Training Activities

Forage agronomy personnel received or gave instruction as follows:

Individual	Timeframe	Training received
Musa Bojang	1/84-1/86	B.S.degree in Agronomy, Colorado State University
Matarr Njie	4/85;11/85-1/86	Thesis research on crop residues in The Gambia, University of Uppsala, Sweden
Ousman Ceesay	6/85-9/85	Thesis research on selenium in Leucaena and soils in The Gambia; University of Ghana
Amadou Jallow	4/84	Farming Systems Workshop, Jenoi
Bambo Ceesay	5/85	On-farm trials-FSR Workshop, Bakau
	5/85-6/85	Seed technology training, Texas A&M, Beeville, TX and University of Florida
Lamin Jobe	5/85	On-farm trials-FSR Workshop, Bakau
	3/86-5/86	Animal nutrition and forage analysis, ILCA, Ethiopia
Kutubo Sanyang	1/86-3/86	Animal nutrition and forage analysis, ILCA, Ethiopia
Salifu Samba	1/86-2/86	Trypanosomiasis course, ITC, Abuko and Keneba
Dembo Touray	1/86-2/86	Trypanosomiasis course, ITC, Abuko and Keneba
S.Russo	4/84	Small ruminant production systems, FSR Workshop lecture, Yundum

Bambo Ceesay S. Russo S. Deffendol Alieu Joof	11/84	Plant identification and sampling, herding study enumerators, Basse
S. Russo	3/85	Animal nutrition for draft animals, First West African Animal Traction Networkshop, Resource person, Lama- and Lome, Togo
S. Russo	5/85	Livestock parameters in FSR, On-farm trials, FSR workshop, Resource person, Bakau
S. Russo	9/85	Forage legumes in The Gambia, Workshop on Potential of Forage Legumes in Sub-Saharan Africa, invited speaker, ILCA, Ethiopia
S. Russo Sol Owens	11/85	Coordinating committee meeting, West Africa Animal Traction Network, Secretariat, Senegal and The Gambia

Appendix B: Publications

Russo, S.L., 1985. Handbook on the use of crop residues for livestock use. MFP/DAHP. Abuko. 11pp.

Russo, S.L., 1985. Forage legumes in The Gambia. ILCA Workshop on the Role of Forage Legumes in Sub-Saharan Africa. Addis Ababa, Ethiopia.

Russo, S., N. Patrick and S. Deffendol, 1985. Conducting village level feeding trials in The Gambia. KSU Farming Systems Research and Extension Symposium, Manhattan, KS.

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Poats, S., J. Lichte, J.Oxley, S. Russo and P. Starkey. 1985. FSSP Networkshop Report No.1. "Animal Traction in a Farming Systems Perspective". FSSP/UF/USAID.

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Russo, S.L., 1986. The Use of Crop Residues for Animal Feed in The Gambia. MFP Technical Report No.11.

Russo, S.L., 1986. Evaluation of Leucaena's Potential in The Gambia. MFP Technical Report No.7.

Russo, S.L., 1986. Introduction of Leucaena leucocephala as a forage crop in The Gambia. Submitted to Leucaena Research Reports, Un. Hawaii, Honolulu.