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PURDUE UNIVERSITY
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PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT

(Contract AID/NE-C-1701)

REPORT ON
SHORT-TERM STAFF ASSIGNMENT

Submitted by
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W. Lafayette, Indiana

May 29-July 14, 1984

PDAAE 746

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(AID Contract-AID/NE-C-1701)

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at the

Instituto Universitario de Tras-os-Montes e Alto Douro
Vila Real, Portugal

and

Universidade de Evora
Evora, Portugal

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Dr. Charles L. Rinykerd
Department of Agronomy
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West Lafayette, Indiana

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FORWARD

This report pertains to my third short-term consulting assignment for the AID funded Portugal University Institutes Development Project. I am proud to have been a part of this project and feel that much has been accomplished since my first assignment in 1981.

During the four-year period I made three trips to Portugal for a total of six months. I consulted with numerous professors and administrators relative to forage production and utilization at the Instituto Universitario de Tras-os-Montes e Alto Douro (IUTAD), Vila Real and the University of Evora. In addition, I taught a forage crops course one term at the University of Evora and presented a total of five seminars at IUTAD, four seminars at the University of Evora, one seminar at the National Plant Breeding Station at Elvas, one seminar at the National Livestock Center in Santarem, and one seminar at a PROCALFER forage crops symposium in Oeiras.

Two M.S. theses resulted from my involvement in this project. Ms. Ana Pires, a soils professor at IUTAD, will complete her M.S. degree at Purdue University under my guidance in December 1985. Her thesis research project was designed and conducted in Portugal with assistance from Dr. J. L. Ahlrichs prior to coming to Purdue University in January 1984. Dr. Ahlrichs is a Purdue University professor that was located at IUTAD from January 1981 to January 1983 as a long-term consultant on this project.

Ms. Susan Fowler, a native of Indiana and a graduate student in the Agronomy Department at Purdue University utilized data from 443 forage samples that I collected in Portugal in 1981 and 1982 and brought back to Purdue University for mineral analyses. Her M.S. thesis was completed in May 1984. An additional 243 forage samples were collected during my trip in 1984 and the mineral analyses of those samples appear in Appendix A of this report.

In November 1984, Ms. Ana Pires and I each presented a paper at the Annual Meeting of the Indiana Academy of Science. The two papers pertained to the mineral composition of forage crops grown in Portugal. Manuscripts will be published in 1984 Proceedings of the Indiana Academy of Science.

Detailed mineral analyses have been conducted on 686 forage samples and the data presented in my three reports. These data represent a wealth of information concerning the mineral status of numbers of forage crops throughout Portugal and should be extremely useful to both agronomists and animal nutritionists. Therefore I strongly encourage those researchers who have provided these samples to publish their data in scientific journals and/or extension publications so that maximum use can be made of these data. These data are useful in identifying mineral nutritional problems of agronomic crops as well as serving to diagnose possible mineral nutritional problems with ruminant animals.

Charles L. Rhykerd

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ACKNOWLEDGEMENTS

It is impossible to adequately recognize everyone who assisted me in my third short-term consulting trip to Portugal. As on previous trips, the AID/Lisbon Office was most cooperative and I wish to acknowledge Michael F. Lukomski, Jose Luis Pinheiro and Luiza Gomes. Their concern and assistance permitted me to make the most efficient use of my time while in Portugal.

At IUTAD I am especially indebted to Prof. Nuno Moreira for hosting me for two and one-half weeks. Despite his very busy schedule he spent many days showing me his experimental plots and typical livestock-forage farms in Northern Portugal. I am also indebted to Dr. Fernando Nunes Ferreira Real, Reitor, Dr. J. Torres Pereira, and the following professors: Armando Mascarenhas Ferreira, Arnaldo Silva, Jorge Azevedo, Joao Coutinho, Ester Portela, Valdemar Carnide, and Afonso Martins.

During my month long stay at the University of Evora numerous administrators and scientists contributed to the productivity and pleasantness of my stay including Dr. Ario Lobo Azevedo, Pedro and Carmo Silveira, J. Dargent Albuquerque, Mario Carvalho, Afonso

Almeida, Ofelia Bento, Jose Avo, Carlos Roquete, and Jose Luis Tirapico.

Although my time spent with PROCALFER was very brief, I had an excellent opportunity to exchange ideas with Dr. Almeida Alves and Dr. P. F. Warnken.

Thanks is also extended to Ms. Vivian Rider, Dr. James Collom, and Dr. D. Woods Thomas of the Purdue University International Programs in Agriculture. Appreciation is also extended to Dr. M. W. Phillips, Head of the Agronomy Department, for providing me with leave time so that I was able to accept this assignment.

ITINERARY

May 29 --	Left W. Lafayette, IN at 1:35 p.m. and arrived in New York at 8:15 p.m.
May 30 --	Arrived in Lisbon at 9:30 a.m. and after brief visit with AID office I continued on to Vila Real arriving at 8:00 p.m.
May 31 & June 1 --	Visited with Nuno Moreira and observed his research plots.
June 2 & 3 -- (Weekend)	Prepared seminar.
June 4 --	Presented seminar "The Role of Nitrogen in Forage Production and Utilization"
June 5 --	Visited with Armando Mascarenhas Ferreira--Zootecnia
June 6 --	Visited with Valdemar Carnide, a plant breeder in the morning. In the afternoon, I attended a soil-plant--animal interdisciplinary monthly seminar.
June 7 --	Tour of northeast Portugal with Nuno Moreira to observe forage research in northeast.
June 8 --	Studied the forage project supported by World Bank.
June 9 & 10 --	Weekend.
June 11 --	Traveled to Chaves in the morning to observe forage research plots. Spent afternoon at the Quinta.
June 12 --	Traveled to Minho to visit some farms.
June 13 --	Holiday. Worked on organizing plant samples of Nuno and Armando to take to Purdue University for analyses.
June 14 --	Finished preparing plant samples and visited with Nuno.
June 15 --	Traveled to Porto with Nuno. Took train to Lisbon. Spent the night in Lisbon as last bus for Evora had already left.
June 16 --	Took bus to Evora and taxi to Mitra. Visited with Dr. Sid James who returns to Utah tomorrow.
June 17 -- (Sunday)	Spent the day with Pedro & Carmo Silveira and Jose Carlos Dargent de Albuquerque.
June 18 --	Visited with Afonso Almeida, Ofelia Bento, Mario de Carvalho. Rosario Oliveira, and Pedro Silveira.

June 19 --	Toured Mitra with Jose Avo.
June 20 --	Met with "Comissao Executiva Tecnica das Herdades Experimentais" relative to the possibiltiy of acquiring more land adjacent to Mitra.
June 21 & 22 --	Holidays.
June 23 & 24 --	Weekend.
June 25 --	Went to Almocreva with Mario Carvalho.
June 26 --	Prepared seminar.
June 27 --	Presented seminar "Effect of N Fertilization on the Culture of Forages and Pastures." Spent several hours in afternoon talking to English class.
June 28 --	Visited with Dr. Herbert Albreghts, the German advisor and Dr. M. B. Jones who arrived in the afternoon.
June 29 --	Holiday. Visited with Dr. M. B. Jones.
June 30 & July 1 --	Weekend.
July 2 --	Visited with Ofelia Bento.
July 3 --	Traveled to Odemira to visit a large dairy cooperative with Afonso Almeida, Ofelia Bento, Pedro Silveira and Manual Cancela d'Abreu.
July 4 & 5 --	Visited with Afonso Almeida.
July 6 --	Traveled to Dareiras with Pedro Silveira to visit a Univ. of Evora farm.
July 7 --	Visited cooperative at Odemira again to collect forage samples to bring back to Purdue University for mineral analysis.
July 8 --	Sunday. Visited with Dargent Albuquerque and Afonso Almeida.
July 9 --	Visited with Avo concerning forages for sheep.
July 10 --	Meeting with Albuquerque, Ricardo, and Pedro Vacas Silveira. In afternoon spoke to English class for two hours and then with Mario Carvalho.

July 11 --	Visited with Rosario Oliveira and later in the morning with Reitor Azevedo. Left for Lisbon with Pedro about 4:30 p.m.
July 12 --	Visited with Jose Luis Pinheiro and Michael Lukomski.
July 13 --	Visited Almeida Alves and Phil Warnken with PROCALFER. Also visited with Andre Dordio.
July 14-31 --	Went to Burkina Faso and returned to Lisbon.
August 1 --	Visited with M. B. Jones in morning prior to his leaving for tour of Europe. Talked to Phil Warnken by phone. Afonso Almeida brought forage samples to take to Purdue University for mineral analysis.
August 2 --	Visited AID office.
August 3 --	Left Lisbon at 11:15 and arrived in Indianapolis at 6:15 p.m.

OBSERVATIONS AND RECOMMENDATIONS

Introduction

It was most encouraging to return to IUTAD and the University of Evora after one and one-half years to see the progress being made in their teaching and research programs as well as the professional training of the faculty. One cannot help but be impressed by the positive attitude, dedication, industriousness, enthusiasm, and spirit of cooperation of the young professors despite their lack of facilities, inadequate research budgets and heavy work-loads due to teaching and research commitments in addition to devoting endless hours to their dissertation research. Hopefully a number of the professors may be able to complete their Ph.D. degrees within the next year or two.

My third trip has given me added confidence that the conclusions I made in my report of my second visit are quite valid. I am listing those conclusions below in case the reader does not have access to my report.

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Conclusions:

Productivities in pasture, forage, and animal production are low in Portugal due to severe climatic and soil limitations. The production of pastures and forages is highly seasonal resulting in a lack of quantity and quality of feed during a considerable portion of the year. Following is a list of recommendations to improve pasture, forage, and animal production:

1. An urgent need to train forage specialists to conduct research to develop the technology for a profitable forage - animal industry.
2. Develop a 12-month pasture and forage calendar utilizing conserved forages.
3. Initiate a forage testing program to educate producers relative to the relationship of forage quality and increased animal performance as well as an aid in balancing rations.
4. Develop technology to assure the establishment of forages including resolving soil acidity and fertility problems.
5. Evaluation of forage species, including cereals, and varieties for pasture and conserved forage.
6. Development of the forage seed industry recognizing that the technology for successful establishment and production of many of the forage legumes must first be developed. If there is not a large demand for certain legumes, especially those requiring high technology for seed production as is the case with

subterranean clover, it would be expected to be more economical to continue to import the seed.

Without doubt the first conclusion regarding the training of forage specialists is the most urgent and significant since the remaining five conclusions require forage specialists trained at the Ph.D. level to resolve the forage - animal production problems in Portugal. In a PROCALFER sponsored seminar I presented at Oeiras on December 14, 1982 I indicated a minimum of 10 Ph.D.'s in the forages area would be required to help resolve the forage - animal production problems. Thus far, only Dr. Ermelinda Pinheiro has obtained her Ph.D. degree from Iowa State University. Professor Nuno Moreira should complete his Ph.D. degree in the very near future and Ms. Ana Pires will soon complete her M.S. degree at Purdue University. Certainly greater urgency must be devoted to training these scientists if rapid progress is to be made in developing the forage - animal industry in Portugal.

Establishment of "Centers of Excellence"

In order to facilitate the training of forage specialists at the Ph.D. level and to develop the necessary forage technology I am recommending the establishment of two "Centers of Excellence" in the area of forage management. One "Center of Excellence" would be located at IUTAD for training scientists and to develop the necessary technology for the forage - animal industry of Northern Portugal. The other "Center of Excellence" would be established at the University of Evora to train scientists and to develop forage technology for the Alentejo and other regions of Southern Portugal.

Because of the nature of the agricultural problems in the Alentejo and the expertise of Reitor Azevedo and some of the present faculty I would also recommend the establishment of a "Center of Excellence in Land Use and Management" at the University of Evora. The purpose of this "Center of Excellence" would be to develop better cropping and tillage systems for this region while reducing soil erosion and improving soil productivity. The research programs associated with this center would provide an excellent opportunity to train scientists and their theses research would develop the technology for the improved cropping and tillage systems while at the same time reduce soil erosion and increase soil productivity.

The development of these "Centers of Excellence" need not require the input of huge sums of money for faculty and facilities. I would encourage maximum use of the present faculty and facilities. Gradual increase in facilities would occur as the number and level of training of the faculty increases.

The establishment of a "Forage Production and Utilization Center of Excellence" will require an interdisciplinary team of very capable scientists working with the soil - plant (forage)-animal complex. The basis for such a team already exists both at IUTAD and the University of Evora. At IUTAD, Professor Nuno Moreira is an extremely competent and well-trained forage specialist capable of providing the leadership along with Animal Science Professors Armando M. Ferreira, and Arnaldo Silva, and Soils Professors Joao Coutinho, Ana Pires, and Ester Portela, to name a few, to provide the nucleus of a highly qualified staff to train graduate students and develop the necessary forage - animal technology. Comparable professors at the University of Evora would include Ermelinda Pinheiro, Ph.D. in forages from Iowa State University, Afonso Almeida, soon to complete his Ph.D. in animal nutrition, along with fellow animal scientists Jose Avo, Ofelia Bento, Carlos Roquete and Manual Cancela d' Abreu, while possible soil scientists would include professors Alfredo Goncalves Ferreira, Mario Carvalho, and Rosario Oliveiro. I would encourage close cooperation between the interdisciplinary team at IUTAD and Evora with an annual workshop to exchange ideas and data.

Publication of New Technology

There is a dire need to make the latest forage production and utilization research data available to farmers as quickly as possible. A very effective method of doing this in the U.S. is through extension publications. During my visit to IUTAD, Nuno Moreira showed me his research plots where he was experimenting with oats and vetch for hay. Based on several years data he felt that he had developed the necessary management practices to produce high yields of high quality hay. However, this technology was not available to farmers. Therefore, I suggested that he write an extension publication outlining the steps involved for producing high yielding, high quality hay. Consequently Nuno wrote an excellent extension type publication and a copy is included in Appendix B to serve as an example of how these type data can be made available to extension personnel, agri-business, and farmers. I would strongly encourage more publications of this type as new technology becomes available. It is important that the researcher be the author, or co-author, so that if there are questions concerning the topic the extension person or farmer knows who to contact. In addition, the researcher receives recognition for his work.

The Portuguese Pasture and Forage Society may want to consider publishing a periodic magazine concerning forage production and utilization which would be directed to extension personnel, agri-business, and forage and livestock producers. This could enable the

organization to expand its membership and the members would have a choice of receiving the applied magazine or the present research journal. Some members may wish to pay an additional fee and receive both publications.

Utilization of Tall Fescue for Forage

The use of tall fescue (Festuca arundinacea) for forage appears to me to be increasing rather rapidly in Portugal. If this is true, animal producers may start noticing adverse effects on animal performance as noted by reduced milk production, increased breeding problems, and reduced weight gains particularly during the warmer part of the growing season and especially under irrigation and the application of nitrogen fertilizer.

Agronomically tall fescue is a fantastic cool-season grass since it tolerates acid, low fertility soils and persists where other grasses fail. However, animal producers that want high animal performance have encountered many animal health problems. Dairy farmers in the U.S. know that milk production drops within 5-6 days after cows are on tall fescue pasture. In addition, cows on predominately tall fescue pasture fertilized with nitrogen often fail to come into heat and calving percentages may be only 40-50% compared to usually 90% or higher.

The incorporation of legumes, such as white clover, into tall fescue pastures tends to prevent many of the above animal health

problems. I would certainly caution against the use of predominately tall fescue pastures for milking animals or pasture for animals during breeding season especially during summer months. The animal health problem is now thought to be associated with an endophyte fungus. Some varieties are known to be endophyte fungus free and appear to give better animal performance. Considerable research is being conducted in the southeastern U.S. at the present time in an attempt to better understand the problem and increase animal performance on tall fescue pastures.

Forage Grasses & Nitrogen vs. Forage Legumes & Grasses

The acid low fertility soils of much of Portugal results in many difficulties in establishing and maintaining many forage legumes. However, tremendous responses to N fertilizer are obtained by cool- and warm-season grasses in Portugal without the addition of lime or large quantities of P or K. Prof. Nuno Moreira has obtained as much as 75-100 kg dry matter per hectare from a kg of N with oats. This is an unusually high response and encourages greater use of grasses fertilized with N. Prof. Armando M. Ferreira has conducted many experiments with corn for silage and is now experimenting with sorghum. Corn and sorghum are warm-season grasses and therefore must be grown during the summer under irrigation in much of Portugal. With these grasses the possibility of obtaining even higher forage yields exists by double cropping a small grain such as oats in the fall,

winter and spring and corn or sorghum in the summer. While this system permits high forage yields, livestock producers must be aware of animal health problems, such as grass tetany and nitrate toxicity, which may be encountered as animal performance is increased. Many of these animal health problems can be avoided by increased use of forage legumes with grasses and/or proper mineral supplementation. Grasses heavily fertilized with N tend to be higher in nitrate and lower in Ca and Mg than legumes.

Biological N-Fixation

Greater emphasis needs to be devoted to studying N-fixation by legumes. Legumes often respond to N fertilizer indicating a lack of nodulation or inefficient strains of N-fixing bacteria. With the improved animal performance obtained by including forage legumes in rations or in mixtures with grasses in pastures, greater urgency needs to be devoted to this research area.

Mineral Analyses of Forage Crops

Forage production in Portugal is limited by acid, low fertility soils. Analysis of foliar growth is a good method of identifying mineral deficiencies. Since very little data existed in 1981 relative to the mineral concentrations of forage crops in Portugal, I started collecting plant samples of commonly grown grasses and legumes in

northern Portugal and the Alentejo region. The plant samples were dried and ground and brought back to Purdue University. Mineral analyses were determined by the emission spectrograph. More than 200 samples were brought back to Purdue University each time I visited Portugal and a total of 686 forage samples have now been analyzed for mineral concentrations. The results of the analyses appear in my reports. Mineral analyses of the 243 forage samples for my 1984 trip appear in Appendix A of this report.

In 1984, Ms. Susan Fowler who was my graduate student wrote her M.S. thesis utilizing the mineral analyses of 443 forage samples from my trips to Portugal in 1981 and 1982. The title and abstract of Ms. Fowler's thesis is as follows:

Fowler, Susan Elizabeth. M.S., Purdue University, May 1984. Mineral Analyses of Forage Crops Grown in Portugal. Major Professor: Charles Rhykerd.

ABSTRACT

Mineral concentrations in forage species must satisfy both the nutritional requirements of the plant as well as the needs of the animal consuming the forage. Analyses of macro and microelements were conducted on plant samples from forage experiments conducted on research farms associated with Instituto Universitario de Tras-os-Montes, Vila Real, and the Universidade de Evora, Evora, Portugal.

The experiments involved in the mineral composition study were divided into three major sections:

1) the effect of fall and spring N applications on oats and vetch grown on high and low fertility soils
2) the effect of plant density and cutting dates on corn grown for silage
3) collection of forage crops grown for hay or silage.

The first group of experiments indicated that oat samples from high fertility soil, with spring N fertilization, had the highest mineral concentrations. Spring N fertilization increased concentrations of N, K, Ca, Mg, Fe, Cu, Zn, and B, and decreased Mn and Ba levels. Vetch samples had higher concentrations of N, P, K, Ca, Mg, Fe, Cu, Zn, Al, and B than oats. Fall N applications increased the concentrations of Mg and Fe and depressed the Cu level.

In the second study, concerning plant density and harvest date of corn for silage, it was found that the concentrations of N, P, Fe, Cu, and Zn in the corn plant samples decreased as the planting density increased from 5 plants/m^2 to 20 plants/m^2 while levels of Mg, Ca, and Al increased. The later cutting date of corn resulted in lower levels of N, Ca, Mn, Cu, and Zn.

In the third group of experiments, the results of the oat study on effect of seeding dates and harvest dates

indicated that mineral concentrations were highest in samples from the first seedings and the early cutting dates. The results from mineral analyses of a collection of forage samples from Vila Real and Evora, revealed many deficient and/or low concentrations within the small grain crops, grasses, and legumes, when harvested as forage crops. According to NRC standards, numerous mineral deficiencies for ruminant rations were also observed.

At the fall meeting of the Indiana Academy of Science I presented a paper concerning the mineral concentrations of forage crops in Portugal utilizing the mineral data from my first two trips to Portugal. The title and abstract of the paper which will be published in the proceedings of the Indiana Academy of Science is as follows:

Survey of the Mineral Composition of Forage Crops in Portugal

C. L. Rhykerd, S. E. Fowler, Afonso de Almeida, A. M.
Ferreira, Nuno Moreira, C. H. Noller, and J. L. Ahlrichs

Agronomy and Animal Sciences Departments, Purdue University, West Lafayette, IN 47907, I.U.T.A.D., Vila Real, Portugal and University of Evora, Evora, Portugal

ABSTRACT

Limited data are presently available concerning the mineral composition of Portuguese forage crops. The

following experiment was conducted to determine the mineral concentrations in forage samples collected in Portugal from university-conducted experiments. Three major studies were made representing oats and vetch, corn, and common forage crops, with each addressing the following objectives:

1) to determine the mineral composition of the forage samples
2) to relate the mineral value to sufficiency levels for the various forage species
3) to compare the mineral values to mineral nutritional requirements of beef cattle, dairy cattle, and sheep
4) to evaluate the quality of the forage and make recommendations relative to its (nutritional) improvement.

Mineral analysis by means of an emission spectrograph of forage samples from Portugal revealed many low concentrations within the small grain crops, forage grasses, and forage legumes, when harvested as forage.

Data obtained in this study emphasize the importance of legumes to Portuguese livestock farmers. Legumes, if properly inoculated, are able to utilize atmospheric N and thereby eliminate the need for N fertilizer. In addition, legumes are high in protein and contain considerably higher concentrations of certain minerals, especially Ca and Mg, which are essential to proper mineral nutrition of growing and lactating ruminant animals.

Response of Forage Crops to Dolomitic Lime

Ms. Ana Pires, a soils professor from IUTAD is presently completing her M.S. degree at Purdue University as my graduate student. She is being supported financially by PROCALFER. Ana initiated her study of the response of forage crops to dolomitic lime at IUTAD in 1981 with assistance from Dr. Jim Ahlrichs, a Purdue University soils professor who was on a two-year assignment at IUTAD. The title and abstract of her thesis appears below.

Pires, Ana Luisa de Figueiredo. M.S., Purdue University, December 1985. Magnesium Studies of Grasses and Legumes in Northern Portugal. Major Professor: C. L. Rhykerd.

ABSTRACT

Two greenhouse experiments were conducted to evaluate crop response to lime. One greenhouse experiment examined corn response to calcitic and dolomitic lime on two selected soils. No significant positive yield response was obtained in the soil which had 1.73 meq Ca^{2+} and 0.31 meq Mg^{2+}/100 g of soil while a positive response was obtained for both types of lime in the soil which had 0.30 meq Ca^{2+} and 0.08 meq Mg^{2+}/100 g of soil. Increase in yield due to dolomitic lime was 27% higher than that obtained with calcitic lime. A second greenhouse experiment evaluated the effect of dolomitic lime on two grasses and two clovers, grown in an acid soil containing

0.20 meq Mg^{2+}/100 g of soil. The dry matter production of tall fescue, white clover and subterranean clover increased 20, 205 and 47%, respectively, with the application of 15 g/pot of dolomitic lime (7500 kg/ha). Ryegrass, unlike the other forages gave an additional increase in production with 30 g/pot (15000 kg/ha). Lime application increased average Mg concentration, of all four forages, to values greater than 0.20%.

A three-year field experiment was conducted to evaluate the changes in Ca, Mg and K concentrations in triticale, from early growth to maturity and its relation with ruminant mineral requirements. All three nutrients decreased with advancing maturity and, for all stages of growth, only the K concentration was above the animal requirements.

A survey was conducted to obtain information on the Ca, Mg and K status of regularly grazed pastures and rye green fodder, established in Tras-os-Montes region, Northern Portugal. Results indicated that a mineral supplement containing Ca and Mg should be included in the ruminant's diet, during the entire grazing period.

Corn ear leaves, sampled at silking time, were also collected through the Tras-os-Montes region in order to identify the soil properties most highly correlated with plant Mg concentration. Although the Mg concentration in

the corn leaves was significantly correlated with some of the soil parameters, all correlation coefficients obtained were very low.

Ana also presented a paper at the Indiana Academy of Science Annual meeting in November 1984. Following is the title and abstract of the paper. A full length manuscript will be published in the Proceedings of the Indiana Academy of Science.

Response of Forage Crops to Dolomitic Limestone

Ana L. Pires, J. L. Ahlrichs, and C. L. Rhykerd

Agronomy Department, Purdue University, West Lafayette, IN and I.U.T.A.D., Vila Real, Portugal

ABSTRACT

A greenhouse experiment was conducted utilizing an acid, sandy loam soil of northern Portugal (xerofluvent, pH (H_2O) = 5.3 to determine the effect of dolomitic lime on dry matter yield and Ca, Mg and K concentrations in subterranean clover (Trifolium subterraneum L.), white clover (Trifolium repens L.), tall fescue (Festuca arundinacea Schreb.) and hybrid ryegrass (Lolium perenne x Lolium multiflorum).

Each forage species was subjected to 3 treatments: 0, 15 and 30 g/pot (4,000 kg soil) of dolomitic limestone

(63.5% $CaCO_3$ and 37.8% $MgCO_3$). Three cuttings were taken during the growing season.

Lime application significantly increased ($P \leq 0.05\%$) the partial and total dry matter production. However, for the grasses tested, an increase was obtained only for the 2nd and 3rd cuttings.

Application of 15 g/pot of dolomite resulted in the nighest yield of tall fescue, subterranean clover and white clover (final pH = 6.0) while the highest total yield for ryegrass was obtained with 30 g/pot (final pH = 6.6).

Ca and K concentrations were not significantly different ($P \leq 0.05\%$) from those found in the control, with the exceptions of significantly higher Ca in subterranean clover and significantly lower K in white clover. Mg concentration increased significantly ($P \leq 0.05\%$) in the forages from pots receiving dolomite and all Mg levels of these forages exceeded 0.20%, the value commonly accepted as sufficient for animal nutrition and for good plant growth.

As would be expected, Ca and Mg levels in the clovers were superior to those of grasses.

Appendix A

Mineral Analysis of Forage Samples:

Vila Real — Page

Nuno Moreira..... 26

Armando M. Ferreira..... 29

Evora

Afonso Almeida

Lab. No. 650-694..... 37-39

Ofelia Bento

Lab. No. 640, 695-720..... 37,39,40

Mario Carvalho

Lab. No. 641-649..... 37

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Nuno Moreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← Percent of Solid				← Micrograms/gram of Solid							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
425	715	.19	1.28	.12	.08	87	36	2	3	17	17	56	<.5
426	716	.16	1.30	.14	.08	77	35	2	2	12	18	85	<.5
427	717	.11	1.17	.10	.06	87	23	1	2	11	9	83	<.5
428	718	.12	1.10	.11	.06	68	29	1	2	12	14	48	<.5
429	719	.13	0.99	.15	.09	85	66	2	3	17	22	71	<.5
430	720	.14	1.44	.16	.08	52	29	2	2	12	15	110	<.5
431	721	.10	1.21	.10	.05	63	19	1	2	10	11	67	<.5
432	722	.11	1.06	.15	.09	58	30	2	4	16	16	103	<.5
433	733	.15	1.57	.16	.09	89	32	2	3	16	16	115	<.5
434	724	.11	1.30	.12	.07	63	37	2	2	11	31	93	<.5
435	725	.15	1.91	.14	.07	96	30	2	3	16	20	168	<.5
436	726	.12	1.41	.13	.06	83	30	2	2	12	13	93	<.5
437	727	.12	1.37	.15	.06	82	24	1	3	13	11	91	<.5
438	728	.23	2.87	.98	.21	52	63	17	11	53	66	61	<.5
439	729	.13	1.36	.14	.08	94	29	2	3	13	18	180	<.5
440	730	.08	1.25	.13	.06	69	30	2	3	12	15	109	<.5
441	731	.12	1.39	.12	.05	65	29	2	3	11	15	88	<.5
442	732	.11	1.39	.16	.09	87	54	2	3	14	26	346	<.5
443	733	.13	1.89	.19	.09	176	242	2	3	14	21	326	<.5
444	734	.15	1.92	.16	.09	136	30	1	2	14	19	215	<.5
445	735	.15	1.60	.15	.08	87	52	2	3	17	20	158	<.5
446	736	.10	1.42	.13	.06	83	24	1	2	12	11	134	<.5
447	737	.16	1.67	.15	.08	71	26	2	3	15	12	91	<.5

Nuno Moreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid - - →				← - - - - - Micrograms/gram of Solid - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
448	738	.14	1.60	.17	.08	86	24	2	2	12	18	138	<.5
449	739	.15	1.58	.18	.07	75	30	2	5	19	18	71	<.5
450	740	.14	1.72	.19	.08	80	29	2	3	17	18	113	<.5
451	741	.15	1.83	.20	.09	101	39	2	4	19	21	243	<.5
452	742	.17	2.72	1.11	.16	65	74	12	21	72	146	39	<.5
453	743	.22	2.92	.88	.17	62	64	14	14	51	76	68	<.5
454	744	.20	3.03	.76	.15	69	60	13	17	63	68	81	<.5
455	745	.20	1.72	1.28	.21	46	64	11	13	53	95	57	<.5
456	746	.20	2.84	1.22	.17	69	58	17	14	62	110	40	<.5
457	747	.27	2.68	.89	.20	55	65	12	12	57	67	50	<.5
458	748	.14	2.39	1.06	.17	51	49	13	14	52	63	46	<.5
459	749	.24	2.75	1.00	.17	54	63	12	11	49	69	70	<.5
460	750	.18	2.26	.98	.20	43	57	13	10	46	60	58	<.5
461	751	.21	2.42	1.13	.18	71	60	11	13	65	83	64	<.5
462	752	.17	2.71	1.12	.19	67	51	12	12	55	70	61	<.5
463	753	.18	2.98	1.12	.20	57	54	18	16	65	68	77	<.5
464	754	.23	3.12	.88	.16	60	57	18	16	72	66	56	<.5
465	755	.29	3.22	.79	.19	65	68	14	14	60	54	75	<.5
466	756	.27	2.45	.94	.18	55	59	11	10	43	49	44	<.5
467	757	.25	3.17	.85	.18	80	63	13	18	77	78	56	<.5
468	758	.18	2.76	1.21	.18	48	56	13	12	49	68	53	<.5
469	759	.19	2.04	.97	.17	54	62	14	10	52	79	202	<.5

Nuno Moreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid- - →				← - - - - - Micrograms/gram of Solid - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
470	760	.20	2.34	1.21	.19	58	64	13	16	66	94	83	<.5
471	761	.32	3.70	.89	.17	76	85	16	14	64	92	90	<.5
472	762	.24	2.72	.98	.17	87	79	13	13	57	84	164	<.5
473	763	.18	2.83	1.31	.18	76	63	15	19	71	97	41	.7
474	764	.32	3.51	.86	.17	72	99	11	15	68	138	65	.7
475	765	.35	3.49	.82	.17	72	93	16	16	74	86	63	.8
476	766	.18	1.95	.16	.08	151	42	2	4	20	30	99	<.5
477	767	.23	2.74	.92	.15	73	95	10	13	57	146	49	.6
478	768	.16	2.44	1.14	.17	77	80	11	22	56	161	25	<.5

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← Percent of Solid				← Micrograms/gram of Solid →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
479	1-15-11	.30	2.35	.43	.29	36	111	4	8	28	108	35	<.5
480	1-15-12	.25	2.30	.35	.27	40	94	3	7	27	86	27	.6
481	1-15-13	.38	2.32	.34	.30	43	111	3	7	30	99	32	.8
482	1-15-14	.28	2.35	.36	.28	40	138	4	8	31	152	40	.8
483	1-15-21	.35	2.18	.40	.33	43	130	5	7	37	142	27	.7
484	1-15-22	.33	2.15	.39	.43	64	127	4	9	45	135	75	.7
485	1-15-23	.26	2.07	.26	.23	41	76	4	6	31	67	43	<.5
486	1-15-24	.30	2.23	.44	.38	58	119	5	9	40	115	25	.7
487	2-15-11	.30	2.59	.45	.19	40	154	5	8	38	145	54	.8
488	2-15-12	.23	2.17	.33	.17	31	99	4	6	32	83	50	.7
489	2-15-13	.20	2.32	.30	.21	37	92	4	6	45	69	49	.6
490	2-15-14	.29	2.49	.43	.26	45	102	4	8	47	76	65	.7
491	2-15-21	.30	2.20	.37	.25	51	113	4	10	41	77	55	.6
492	2-15-22	.29	2.32	.35	.28	56	100	4	10	38	65	44	.6
493	2-15-23	.27	2.32	.33	.30	60	101	4	9	42	78	51	.7
494	2-15-24	.33	2.29	.40	.35	55	102	4	10	41	70	90	.7
495	2-15-31	.24	2.32	.39	.36	51	160	4	8	37	198	64	.8
496	2-15-32	.20	2.33	.36	.35	72	170	4	7	36	215	128	.9
497	2-15-33	.24	2.03	.38	.39	72	140	5	8	45	153	121	.8
498	2-15-34	.27	2.46	.43	.47	54	159	4	9	46	178	132	7
499	3-15-11	.31	2.92	.51	.27	42	166	4	9	48	168	85	.8
500	3-15-12	.24	2.47	.39	.21	36	110	4	8	41	103	52	.9

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← Percent of Solid →				← Micrograms/gram of Solid →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
501	3-15-13	.24	2.57	.36	.26	46	103	4	8	54	72	52	.7
502	3-15-14	.23	2.46	.39	.23	43	103	4	7	39	85	57	.8
503	3-15-21	.29	2.50	.37	.29	44	113	5	10	42	88	40	.9
504	3-15-22	.28	2.43	.37	.28	45	126	5	10	39	106	51	.9
505	3-15-23	.29	2.94	.39	.35	65	110	4	11	51	88	60	.7
506	3-15-24	.32	2.82	.39	.32	76	148	5	10	43	136	54	.7
507	3-15-31	.24	2.56	.42	.35	43	145	4	7	36	181	53	.7
508	3-15-32	.19	2.39	.36	.30	55	131	4	7	42	154	67	.7
509	3-15-33	.24	2.74	.38	.35	64	123	4	7	46	140	100	.8
510	3-15-34	.24	2.73	.37	.37	63	140	4	7	43	172	72	.8
511	4-15-13	.26	2.48	.43	.22	46	148	4	8	42	133	50	1.0
512	4-15-14	.27	2.62	.44	.22	45	124	4	8	46	112	55	.7
513	4-15-31	.23	2.53	.41	.36	56	137	4	8	48	160	111	.7
514	4-15-32	.23	2.50	.41	.40	53	138	4	8	44	153	83	.7
515	4-15-33	.18	2.06	.43	.42	76	104	4	8	47	111	98	.8
516	4-15-34	.22	2.31	.37	.36	60	104	4	7	45	97	103	.8
517	5-15-11	.47	4.60	.74	.43	69	258	7	15	60	310	74	1.2
518	5-15-12	.28	2.83	.42	.22	40	126	4	9	40	116	41	.9
519	5-15-13	.26	2.78	.56	.30	38	163	4	9	39	183	101	1.0
520	5-15-14	.25	2.92	.43	.29	44	103	4	9	46	92	40	.8
521	5-15-21	.26	2.49	.31	.30	44	87	4	8	38	61	37	.6
522	5-15-22	.28	2.70	.32	.26	45	116	5	9	34	113	31	.8

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample NO.	← -Percent of Solid - →				← - - - - - Micrograms/gram of Solid - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
523	5-15-23	.35	3.25	.38	.35	67	129	5	11	41	112	42	.6
524	5-15-24	.31	2.55	.43	.36	76	190	6	13	45	191	26	1.0
525	5-15-31	.26	2.51	.42	.40	62	139	5	9	43	139	36	1.0
526	5-15-32	.23	2.68	.41	.33	61	135	5	9	42	138	48	.8
527	5-15-33	.25	2.82	.45	.45	75	123	4	8	47	111	61	.6
528	5-15-34	.26	2.43	.41	.41	79	129	5	10	46	113	41	.8
529	6-15-11	.28	2.52	.38	.21	42	160	4	10	31	143	42	.8
530	6-15-12	.25	2.45	.42	.29	48	140	4	10	35	128	45	1.0
531	6-15-13	.24	2.93	.43	.32	52	120	4	9	40	111	66	.9
532	6-15-14	.26	2.47	.36	.23	40	129	4	8	29	117	38	.8
533	6-15-21	.31	2.46	.33	.30	43	104	5	7	38	84	28	1.0
534	6-15-22	.25	2.45	.38	.35	60	100	5	9	41	76	39	1.1
535	6-15-23	.26	2.42	.33	.34	57	87	5	9	37	64	37	.8
536	6-15-24	.25	2.27	.25	.23	40	69	3	6	36	59	41	.6
537	6-15-31	.20	2.33	.48	.38	69	179	4	6	59	259	44	.9
538	6-15-32	.19	2.15	.45	.32	89	186	4	5	45	270	45	1.1
539	6-15-33	.23	2.11	.44	.33	101	228	4	6	49	331	32	1.0
540	6-15-34	.23	2.36	.41	.31	70	176	4	4	46	274	53	1.1
541	7-15-11	.35	2.92	.56	.28	42	233	5	14	44	250	47	1.1
542	7-15-12	.29	2.77	.43	.25	47	127	5	10	43	99	33	.9
543	7-15-13	.28	2.47	.45	.26	51	123	5	11	43	89	27	.8
544	7-15-14	.29	2.54	.46	.23	41	135	5	9	36	118	27	.8

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← --Percent of Solid - →				← - - - - - - Micrograms/gram of Solid - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
545	7-15-21	.27	2.39	.42	.33	42	100	4	10	40	70	34	.9
546	7-15-22	.32	2.82	.40	.34	64	117	5	11	41	95	56	.8
547	7-15-23	.27	2.36	.37	.33	71	100	5	11	42	102	44	.9
548	7-15-24	.34	2.91	.43	.37	65	137	5	12	49	109	63	1.1
549	7-15-31	.23	2.37	.52	.41	57	126	5	8	47	135	72	1.0
550	7-15-32	.29	2.76	.47	.39	73	138	5	9	53	165	64	.8
551	7-15-33	.22	2.31	.47	.41	98	125	5	9	55	155	66	.9
552	7-15-34	.26	2.84	.41	.43	57	105	4	8	50	108	59	.9
553	8-15-11	.25	2.05	.32	.30	38	81	3	7	43	65	30	.8
554	8-15-12	.27	1.99	.41	.29	54	141	5	9	29	181	30	1.1
555	8-15-13	.24	2.35	.34	.30	58	122	4	7	35	138	29	.9
556	8-15-14	.25	2.07	.34	.28	48	103	4	7	34	90	27	.8
557	8-15-21	.33	2.40	.36	.35	44	140	5	10	33	123	63	.7
558	8-15-22	.28	2.13	.32	.33	62	94	4	7	37	74	54	.7
559	8-15-23	.31	1.95	.30	.33	54	140	4	7	34	164	40	.9
560	8-15-24	.29	1.82	.29	.31	51	129	4	6	33	151	37	.8
561	8-15-31	.24	2.00	.38	.37	55	184	4	6	43	275	35	.8
562	8-15-32	.24	1.86	.39	.35	75	185	4	5	43	291	36	.9
563	8-15-33	.29	2.11	.46	.42	82	247	4	5	47	435	94	.9
564	8-15-34	.27	2.10	.42	.37	83	170	4	5	47	250	35	1.0

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid- - →				← - - - - - - Micrograms/gram of Solid - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
565	1-5-11	.25	2.39	.47	.29	40	143	3	6	31	156	46	.9
566	1-5-12	.26	2.64	.50	.34	40	146	3	6	32	177	43	.8
567	1-5-13	.21	2.24	.41	.43	44	99	3	6	37	108	51	1.0
568	1-5-14	.23	2.13	.46	.35	41	180	3	7	33	223	59	1.1
569	1-5-21	.24	1.82	.37	.32	47	138	4	6	32	190	10	<.5
570	1-5-22	.19	1.88	.41	.36	47	177	3	7	29	272	11	<.5
571	1-5-23	.18	1.84	.42	.42	74	153	3	7	34	208	11	<.5
572	1-5-24	.16	1.51	.36	.31	44	151	3	5	25	224	3	<.5
573	2-5-21	.23	2.57	.42	.35	5	118	4	9	38	111	105	<.5
574	2-5-22	.23	2.01	.40	.34	45	110	3	8	37	90	81	<.5
575	2-5-23	.21	1.95	.37	.38	51	104	3	8	38	97	60	<.5
576	2-5-31	.23	2.20	.38	.35	46	114	4	7	34	130	59	<.5
577	2-5-32	.21	1.93	.37	.33	54	109	4	8	39	101	37	<.5
578	2-5-33	.20	1.91	.37	.36	61	118	4	8	43	132	31	<.5
579	2-5-34	.24	2.32	.37	.38	47	127	4	8	39	129	53	<.5
580	2-5-11	.26	3.05	.45	.34	56	135	4	10	46	94	46	<.5
581	2-5-12	.19	2.35	.45	.28	35	135	3	7	42	172	52	<.5
582	3-5-13	.17	2.29	.43	.29	46	163	3	6	42	207	62	<.5
583	3-5-14	.19	2.39	.41	.26	37	117	3	6	39	133	59	<.5
584	3-5-21	.22	2.03	.42	.38	35	171	3	7	32	232	32	<.5
585	3-5-22	.21	2.27	.39	.33	48	143	4	7	34	177	38	<.5
586	3-5-23	.19	2.02	.37	.44	57	102	3	8	44	98	46	<.5

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid - →				← - - - - Micrograms/gram of Solid - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
587	3-5-24	.22	2.43	.42	.42	47	135	3	8	43	153	50	<.5
588	4-5-11	.21	2.52	.53	.27	36	161	3	8	43	184	60	<.5
589	4-5-12	.19	2.23	.48	.25	33	144	3	7	38	166	59	<.5
590	4-5-13	.21	2.28	.47	.25	39	168	3	7	42	198	62	<.5
591	4-5-14	.21	2.59	.43	.23	39	127	3	7	42	131	47	<.5
592	4-5-21	.21	2.16	.43	.35	46	137	3	7	36	157	65	<.5
593	4-5-22	.20	1.97	.43	.34	50	162	3	9	40	183	55	<.5
594	4-5-23	.18	1.89	.41	.41	55	124	3	8	49	133	47	<.5
595	4-5-24	.21	2.08	.36	.35	45	124	3	8	40	131	57	<.5
596	4-5-31	.17	1.97	.49	.41	60	237	3	7	39	370	42	<.5
597	4-5-32	.17	1.76	.37	.28	46	173	3	7	31	257	27	<.5
598	4-5-33	.16	1.93	.46	.39	80	168	3	7	49	228	38	<.5
599	4-5-34	.19	2.13	.43	.37	49	163	3	7	36	239	32	<.5
600	5-5-11	.22	3.02	.51	.28	46	145	4	8	40	163	53	.7
601	5-5-12	.37	5.01	.79	.46	65	191	6	14	68	200	77	.8
602	5-5-13	.23	3.05	.46	.34	76	118	3	8	42	110	47	.6
603	5-5-14	.24	2.71	.49	.32	44	143	4	8	40	151	41	.6
604	5-5-21	.30	2.89	.49	.46	49	125	4	8	34	135	38	.6
605	5-5-22	.25	3.07	.42	.38	46	119	4	8	34	123	32	.6
606	5-5-23	.26	2.89	.46	.47	75	100	4	10	37	68	33	<.5
607	5-5-24	.25	2.38	.55	.45	61	152	5	9	38	159	43	<.5
608	5-5-31	.19	2.18	.44	.36	50	133	3	6	35	172	20	<.5

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid - →				← - - - - - Micrograms/gram of Solid - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
609	5-5-32	.21	2.20	.43	.31	47	166	3	6	30	246	42	.6
610	5-5-33	.23	2.32	.44	.41	74	187	3	7	41	268	30	<.5
611	5-5-34	.23	2.41	.41	35	61	160	4	7	40	224	30	.6
612	6-5-11	.25	2.77	.47	.32	42	161	4	9	35	194	67	.8
613	6-5-12	.20	2.33	.45	.36	48	127	3	9	41	130	59	<.5
614	6-5-13	.22	2.61	.43	.33	49	139	3	8	35	160	45	<.5
615	6-5-14	.26	2.95	.47	.35	49	214	3	8	39	301	61	<.5
616	6-5-21	.27	2.65	.39	.36	41	104	4	7	30	103	20	<.5
617	6-5-22	.21	2.07	.40	.41	54	135	4	9	28	135	23	<.5
618	6-5-23	.23	2.52	.37	.38	62	121	4	15	29	113	16	<.5
619	6-5-24	.26	2.58	.33	.29	54	107	4	7	36	113	48	.6
620	7-5-11	.25	2.76	.58	.32	60	146	4	11	53	129	48	.6
621	7-5-12	.24	2.66	.44	.25	42	107	4	9	35	96	35	.6
622	7-5-13	.23	2.79	.49	.33	60	134	4	8	49	111	41	<.5
623	7-5-14	.25	2.71	.47	.26	53	124	4	8	37	122	36	<.5
624	7-5-21	.24	2.83	.41	.40	46	84	3	7	38	71	27	<.5
625	7-5-22	.23	2.63	.40	.38	61	105	4	8	35	95	53	<.5
626	7-5-23	.19	2.15	.37	.37	77	102	4	8	35	88	35	<.5
627	7-5-24	.22	2.67	.41	.43	63	82	4	8	41	65	47	.6
628	7-5-31	.22	2.23	.47	.36	73	203	4	9	41	299	36	<.5
629	7-5-32	.22	2.42	.46	.40	88	218	4	8	38	353	27	<.5
630	7-5-33	.19	2.12	.37	.34	75	120	3	7	56	156	26	<.5

Armando M. Ferreira
University Institute at Vila Real (IUTAD)
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid - →				← - - - - - - Microgram of Solid - - - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
631	7-5-34	.21	2.21	.41	.42	68	151	3	8	42	195	20	<.5
632	8-5-11	.20	1.77	.40	.31	41	108	3	6	30	116	60	<.5
633	8-5-12	.17	1.82	.37	.30	75	133	3	6	33	161	27	<.5
634	8-5-13	.17	1.59	.30	.23	50	134	3	5	23	172	26	<.5
635	8-5-14	.25	2.03	.39	.32	43	146	3	8	30	160	37	.6
636	8-5-21	.18	1.59	.43	.39	48	163	4	6	28	230	26	.6
637	8-5-22	.18	1.71	.42	.41	98	175	5	6	38	266	61	<.5
638	8-5-23	.17	1.41	.30	.32	67	130	3	5	32	196	22	<.5
639	8-5-24	.20	1.75	.40	.43	65	156	4	6	31	208	26	<.5

Rhykerd
University of Evora
Forage Samples

Lab. No.	Sample No.	← - Percent of Solid - →				← - - - - - Micrograms/gram of Solid - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
640	Water Hyacinth	.24	3.41	1.13	.56	15	30	45	6	50	55	35	2.0
641	1	.16	0.76	.13	.08	86	150	2	2	16	225	922	.6
642	2	.17	1.17	.15	.10	137	155	2	1	15	324	186	<.5
643	3	.19	1.04	.24	.13	111	587	3	1	16	1191	1473	1.0
644	A	.18	1.14	.09	.08	88	83	2	3	11	40	157	.6
645	B	.19	1.14	.11	.08	67	33	2	3	12	21	196	<.5
646	C	.20	1.28	.14	.09	98	52	2	3	15	23	110	<.5
647	D	.20	1.43	.12	.06	32	28	1	2	12	20	70	<.5
648	E	.19	1.74	.17	.08	40	33	2	3	12	14	159	<.5
649	F	.21	1.92	.25	.10	47	40	3	4	14	14	106	.6
650	M1	.26	2.32	.32	.30	61	146	6	4	25	78	2285	.9
651	M2	.17	0.96	.34	.24	198	68	10	4	24	39	8009	.9
652	M3	.11	.68	.32	.19	129	44	9	3	16	43	6932	.6
653	M4	.08	.65	.28	.16	108	39	9	4	15	37	5692	<.5
654	M5	.09	.88	.34	.24	207	87	11	3	19	67	6527	.7
655	M6	.09	1.41	.25	.14	100	50	4	2	11	42	1422	<.5
656	M7	.24	1.02	.32	.23	98	166	6	4	23	204	8756	<.5
657	M8	.42	3.40	.36	.22	68	97	7	6	34	61	1662	1.2
658	M9	.32	1.64	.81	.42	47	115	30	7	39	84	4383	2.7
659	M10	.08	1.21	.60	.28	41	99	22	3	16	104	3794	2.8
660	SE1H84	.27	2.36	1.09	.22	107	397	25	6	35	798	1866	1.4
661	SE2H84	.23	1.92	.88	.21	138	212	21	7	66	429	2690	.7

Rhykerd
University of Evora
Forage Samples

Lab. No.	Sample No.	← - Percent of Solid - →				← - - - - - Micrograms/gram of Solid - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
662	GR1H84	.25	2.14	.27	.08	43	53	4	3	16	44	1533	1.3
663	GR2H84	.45	2.70	.49	.17	38	93	4	4	26	93	2273	2.3
664	GR3H84	.38	3.09	.61	.20	46	89	9	5	27	79	1862	1.6
665	SE3H84	.31	2.36	1.40	.29	213	248	44	9	55	224	1613	.9
666	LU2H84	.27	2.82	1.31	.31	36	297	31	9	29	268	2401	1.0
667	LU3H84	.27	1.46	1.83	.29	41	202	29	7	25	130	776	1.2
668	SCL1H84	.28	1.79	.92	.22	90	316	16	9	43	244	4155	1.1
669	SCL2H84	.21	1.71	1.21	.25	38	171	13	7	24	169	3866	1.2
670	CL1H84	.46	2.74	.93	.18	73	171	23	6	29	124	1544	1.2
671	CL3H84	.34	2.23	1.37	.45	51	164	28	10	37	106	4229	2.1
672	MI1	.26	1.85	.31	.12	147	90	4	5	34	60	628	.8
673	MI2	.22	1.84	1.12	.20	50	287	27	6	21	50	355	.7
674	MI3	.28	1.80	.26	.11	109	120	6	4	31	64	477	.8
675	MI4	.17	1.77	.87	.18	114	183	19	6	34	145	790	1.3
676	MI5	.27	1.87	1.09	.20	37	104	43	6	22	70	926	1.1
677	MI6	.26	2.40	1.15	.20	41	114	37	9	27	57	774	.6
678	MI7	.25	1.34	.25	.11	90	115	6	4	34	45	527	.9
679	MI8	.28	3.05	.89	.32	44	101	36	7	26	32	2361	1.1
680	MI9	.30	3.39	.99	.27	40	92	28	8	26	21	997	.8
681	MI10	.24	2.77	.87	.24	76	135	19	8	38	34	915	.8
682	MI11	.32	2.84	1.02	.31	90	311	25	7	48	66	2377	1.0
683	MI12	.17	1.69	.85	.23	104	100	16	5	25	65	958	.9

Rhykerd
University of Evora
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid- - →				← - - - - -Micrograms/gram of Solid - - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
684	MI13	.20	1.83	.88	.26	108	161	15	7	34	123	1402	1.2
685	MI14	.29	2.86	1.18	.24	56	149	38	8	29	65	809	.7
686	MI15	.26	1.43	.22	.10	88	53	6	3	29	32	498	1.0
687	MI16	.19	1.98	1.08	.20	43	114	24	5	20	86	1503	.8
688	MI17	.31	3.55	.85	.31	56	109	31	9	28	32	1683	.8
689	MI18	.42	3.35	.44	.16	172	184	5	8	48	49	1401	1.4
690	MI19	.31	2.25	.42	.13	182	78	5	6	39	37	798	1.2
691	MI20	.20	2.46	1.11	.22	39	78	26	6	20	23	3004	.7
692	MI21	.23	2.54	1.13	.24	60	185	28	8	27	103	960	.6
693	MI22	.22	1.41	.91	.28	99	219	20	6	34	236	1971	1.5
694	MI23	.25	1.55	.90	.23	116	384	19	8	47	369	2843	1.4
695	S_1-Rep I	.21	1.42	.34	.11	116	150	7	3	17	196	1024	1.1
696	S_1-Rep II	.20	1.36	.51	.13	151	506	8	2	18	902	1980	1.0
697	S_1-Rep III	.29	1.62	.53	.14	107	387	9	3	27	517	806	1.5
698	S_1-Rep IV	.33	2.19	.81	.16	150	371	17	5	34	405	881	1.2
699	S_1-Rep I Aveia	.17	1.24	.11	.09	108	94	2	2	16	18	1634	1.0
700	S_1-Rep II Aveia	.25	1.26	.15	.11	188	54	2	3	19	31	2433	.9
701	S_1-Rep III Aveia	.27	1.43	.22	.10	104	66	3	3	21	23	1617	1.1
702	S_1-Rep IV Aveia	.24	1.93	.25	.12	107	64	3	2	19	18	2203	.9
703	S_1-Rep I Vicia	.26	2.22	.60	.17	67	268	16	3	37	51	774	1.0
704	S_1-Rep II Vicia	.31	1.97	.75	.24	92	122	12	3	37	101	1717	1.2

Rhykerd
University of Evora
Forage Samples

Lab. No.	Sample No.	← -Percent of Solid - - →				← - - - - - -Micrograms/gram of Solid - - - →							
		P	K	Ca	Mg	Mn	Fe	B	Cu	Zn	Al	Na	Mo
705	S_1-Rep III Vicia	.34	2.51	.69	.16	57	112	16	3	28	84	647	1.9
706	S_1-Rep IV Vicia	.34	2.89	.62	.15	54	95	19	4	35	43	681	1.3
707	F_1-Rep I	.27	1.69	.72	.17	126	124	12	4	26	110	2898	1.1
708	F_1-Rep II	.28	1.54	.52	.17	172	173	7	4	26	166	1792	1.1
709	F_1-Rep III	.27	1.64	.60	.13	158	176	9	4	24	172	1667	.9
710	F_1-Rep IV	.33	2.19	.58	.16	136	309	13	4	35	314	1436	1.6
711	F_2-Rep I	.18	1.00	.33	.14	87	70	6	2	15	31	2215	1.0
712	F_2-Rep II	.20	1.46	.41	.15	100	60	7	2	21	28	3127	1.0
713	F_2-Rep III	.22	1.37	.51	.11	95	97	8	3	18	82	1322	1.1
714	F_2-Rep IV	.23	1.66	.52	.12	130	100	10	3	24	71	2051	1.1
715	S_2-Rep I	.17	1.36	.53	.15	105	227	9	3	14	401	2039	1.2
716	S_2-Rep II	.25	1.24	.87	.22	164	278	11	4	35	364	2409	1.2
717	S_2-Rep III	.20	1.27	.53	.12	151	163	9	4	22	212	1583	.8
718	S_2-Rep IV	.22	1.46	.54	.12	145	342	9	4	23	496	1303	.9
719	S_2-Aveia	.19	0.88	.15	919	104	38	2	2	15	18	1715	.8
720	S_2-Vicia	.20	1.57	.66	.16	55	54	13	2	23	45	1124	1.0

APPENDIX B

Extension-type Publication by Nuno Moreira

IUTAD
INSTITUTO UNIVERSITÁRIO DE TRÁS-OS-MONTES E ALTO DOURO
Série Divulgação nº 6
FORRAGENS E PASTAGENS

CONSOCIAÇÃO DE AVEIA COM ERVILHACA

COMO OBTER UMA ALTA PRODUÇÃO COM UM SÓ CORTE DE FORRAGEM

NUNO MOREIRA
Assistente do Departamento de Fitotecnia do IUTAD

INTRODUÇÃO

As épocas de escassez de pastos para os animais são um problema a resolver pelos criadores, e em muitos casos reduzem bastante as produções que se poderiam obter na criação desses animais.

Em Trás-os-Montes são épocas de escassez de pastos o Inverno e o Verão. Nas zonas mais frias, como a chamada Terra Fria Transmontana é especialmente no Inverno que esta escassez se faz sentir, enquanto que nas zonas mais quentes como o Douro Superior e a Terra Quente é no Verão.

Uma forma de resolver este problema é produzir feno ou silagem em quantidade e a baixos preços. Porém quando não há rega, é limitada a escolha de culturas que o permitem obter nessas condições.

Com esse objectivo têm-se desenvolvido no país as consociações de aveia com ervilhaca, pelas vantagens que têm de crescerem bem na época das chuvas sem necessidade de rega e sem serem exigentes quanto ao terreno em que são cultivadas.

Nem sempre porém são feitas de forma a se conseguir uma produção elevada num só corte, como convém quando se quer obter feno ou silagem. Essa a razão deste trabalho — divulgar as técnicas que devem ser seguidas para se obter uma alta produção de forragem com um só corte.

PREPARAÇÃO DO TERRENO

É uma cultura pouco exigente e por isso também a preparação do terreno pode e deve ser superficial e pouco dispendiosa.

Em geral cultiva-se a aveia com ervilhaca logo após outra cultura, por exemplo a seguir ao trigo ou ao centeio em terrenos de sequeiro, ou mesmo logo após uma cultura de Verão quando em terrenos de regadio. Assim, a preparação do terreno deverá ser feita no início do Outono, com uma ou duas passagens de escarificador logo após as primeiras chuvas. A cultura será semeada como iremos ver adiante 2 a 4 semanas depois, enterrando-se a semente com passagem superficial de grade ou de escarificador com barra, de forma a que sejam destruídas as ervas daninhas que entretanto nasceram, sem trazer novas sementes dessas ervas para a superfície.

SEMENTEIRA

O principal é saber o que semear e qual a melhor altura para o fazer.

VARIEDADES E DENSIDADE DE SEMENTEIRA

A escolha das sementes a usar é importante pois há variedades que produzem mais que outras. Em vários anos de ensaio em

Vila Real, a Aveia Boa Fé foi a que produziu mais e quanto mais bem cultivada maior é a sua vantagem sobre as outras. Quanto às ervilhacas, é preciso que cresçam bem até à altura do corte, que resistam ao frio e que se adaptem a solos que não são dos melhores. A ervilhaca vilosa é, das que se encontra semente no mercado, a que mais interesse tem.

É preciso também saber quanto se deve semear. Os ensaios por nós feitos indicam que utilizar uma mistura de 80 kg de aveia Boa Fé e 20 kg de ervilhaca vilosa por hectare, é uma boa solução se se usar uma correcta adubação. A alguns pode parecer pouca a quantidade de ervilhaca, mas é preciso atender a que a semente é cara e que se a ervilhaca dominar a cultura, embora a forragem tenha melhor qualidade, rende menos em quantidade, a cultura tomba quando está crescida e dificulta quer o corte quer a fenação.

DATAS DE SEMENTEIRA

Como o que se pretende é obter uma alta produção num só corte para conservar, as datas de sementeira não são as mesmas que quando se semeiam ferrejos para cortar ou pastar no Inverno, em que as sementeiras são muito temporãs.

A escolha da melhor altura para semear deve ter em conta três aspectos. O primeiro é que as plantas nasçam e cresçam um pouco antes dos frios mais rigorosos do Inverno, para que assim tenham a resistência necessária. O segundo aspecto é permitir que entre a preparação do terreno com o escarificador às primeiras chuvas e a sementeira, decorram 2 a 4 semanas pelo menos, para que nasçam as ervas daninhas (infestantes) e sejam destruídas quando se faz a sementeira. O terceiro aspecto a ter em conta, nos terrenos mais férteis, é evitar que a aveia cresça demasiado antes do Inverno, o que abafaria muito a ervilhaca e se o Inverno for muito chuvoso poderia "melar" a produção.

Em ensaios realizados em Vila Real com a aveia Boa Fé (*Fig. 1*), verificamos que a melhor produção de aveia se obteve com sementeiras em fins de Outubro, pois as sementeiras mais cedo infestavam-se muito com ervas daninhas e as realizadas mais

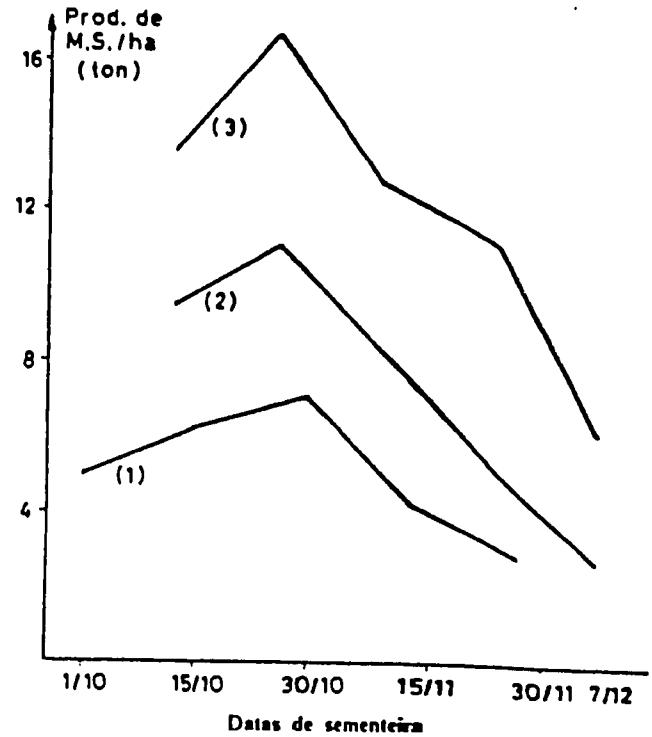


Fig. 1 — Produções de matéria seca/ha de aveia Boa Fé aproveitada num só corte. Resultados de ensaios de datas de sementeira em Vila Real. (1) solo de encosta em 1981/82, (2) solo de encosta em 82/83 e (3) solo de baixa em 82/83.

tarde tinham produções mais baixas. A experiência e observações que temos feito em campos de cultura confirmam os resultados dos ensaios.

Dadas as grandes variações climáticas na região de Trás-os-Montes, consideramos que as datas de sementeira devem, consoante as zonas, ser estabelecidas a partir das seguintes orientações:

zonas mais frias, como as áreas do planalto de Miranda e outras áreas da Terra Fria
— **10 a 20 de Outubro**

zonas de transição, em áreas de altitudes dos 450 aos 600 metros
— **20 a 30 de Outubro**

zonas mais quentes do Douro Superior e da Terra Quente
— **1 a 15 de Novembro**

FERTILIZAÇÃO

A adubação azotada é da maior importância e indispensável à obtenção de elevadas produções.

Além da adubação azotada, há que ter em atenção a adubação de fósforo e potássio e por vezes a correcção calcária, caso haja necessidade, mas ambas devem ser praticadas a partir das análises do solo que se quer cultivar e das recomendações do laboratório de solos.

Quanto à adubação azotada há duas situações diferentes a considerar:

1.ª SITUAÇÃO — em terrenos de encosta de média a baixa fertilidade, em geral "terrenos de cereal"

à sementeira — 100 kg/ha de sulfato de amónio ou de nitrolusal 20,5%, ou caso seja necessário adubar com fósforo e potássio o equivalente de azoto num adubo composto

em cobertura — 400 a 500 kg/ha de nitrolusal 20,5%

2.ª SITUAÇÃO — em terrenos de baixas, de alta fertilidade, em geral terrenos de horta, de regadio ou "terras frescas"

à sementeira — não há necessidade de adubo azotado

em cobertura — 200 a 250 kg/ha de nitrolusal 20.5%.

Na *Fig. 2* apresentam-se resultados médios de dois anos de ensaio em duas localizações, correspondentes a estas duas situações consideradas.

Tem grande importância também fazer a aplicação da adubação azotada de cobertura na altura própria, correspondendo ao fim do afilhamento ou início do encanamento da aveia, o que em geral significará as seguintes datas:

Douro Superior e Terra Quente
1.ª quinzena de Fevereiro

Áreas de Transição
2.ª quinzena de Fevereiro

Terra Fria
1.ª quinzena de Março

ÉPOCA DE CORTE

Na Primavera, após a aplicação da adubação azotada de cobertura e quando

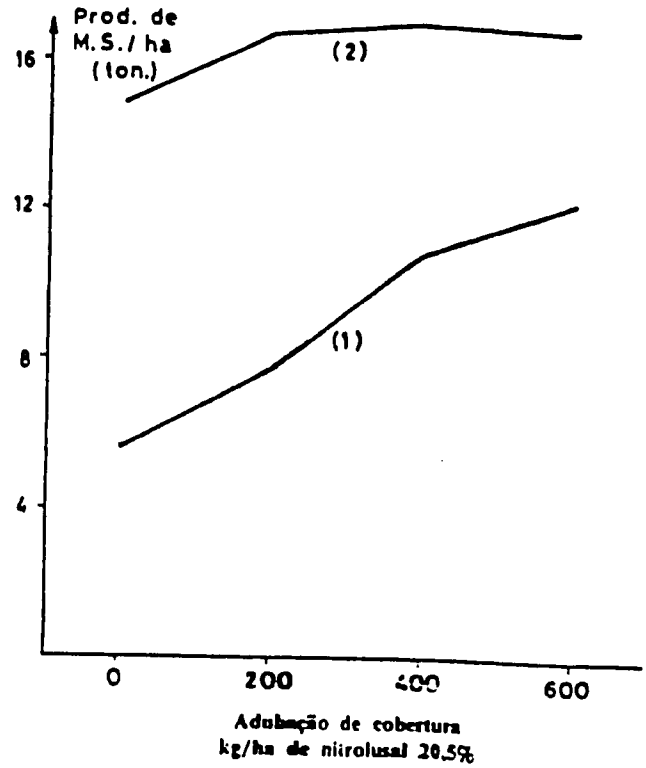


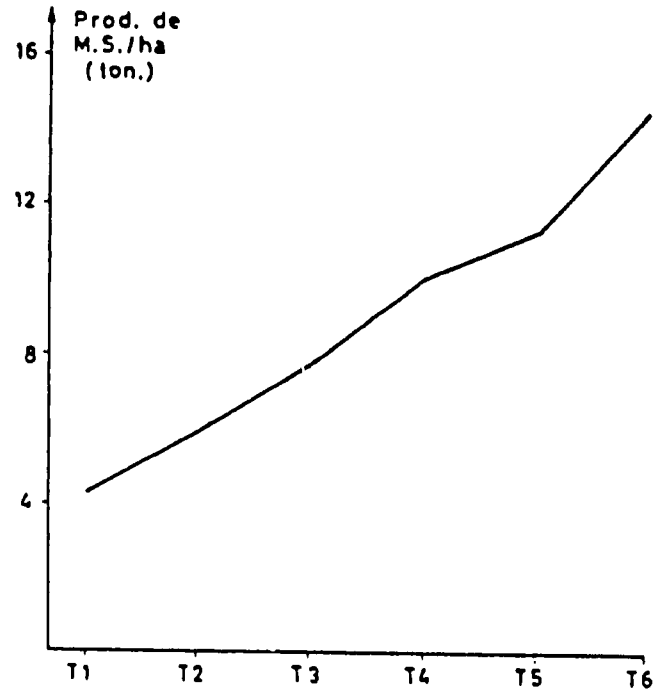
Fig. 2 — Produções médias de matéria seca/ha de (1) consociação de aveia Boa Fé e ervilhaca vilosa em solo de encosta e (2) Aveia Boa Fé em solo de baixa.
Vila Real, IUTAD, 1981/82 e 82/83.

as temperaturas começam a ser favoráveis, o crescimento desta cultura é muito rápido e mantém-se pelo menos até ao estado de grão leitoso/grão pastoso da aveia, como se pode ver nos resultados de ensaios feitos no IUTAD (*Fig. 3*).

É nessa altura que se deve cortar se se quer obter uma alta produção. Cortar mais cedo melhora a qualidade da forragem, mas sacrifica bastante a quantidade da produção, e cortar mais tarde pouco ou nada acrescenta à quantidade, perdendo-se em qualidade no feno ou silagem que se obtém.

Quem pretenda fazer feno deverá cortar quando a aveia esteja em grão leitoso, pois se o grão estiver mais adiantado, ao mexer-se no feno para encordoar ou revirar, perde-se grão que cai. Se o agricultor quer ensilar, deve cortar com a aveia já em grão pastoso, já que não há riscos de perda de grão e a forragem tem então um pouco menos de água o que é benéfico para a ensilagem.

Quem ainda não tenha experiência com esta cultura perguntará ou quererá saber em que data é que colhe. Claro que isso varia de região para região e de ano para ano, consoante os anos sejam mais frios ou mais



T1 — 15/4/81 — Encanamento da aveia
T2 — 27/4/81 — Encanamento da aveia
T3 — 8/5/81 — Emborrachamento
T4 — 18/5/81 — Espigamento
T5 — 29/5/81 — Floração/Início grão
T6 — 8/6/81 — Grão pastoso

Fig. 3 — Evolução das produções de matéria seca/ha com o avançar da maturação numa consociação de aveia Boa Fé e ervilhaca villosa.
Vila Real. IUTAD. 1980/81

quentes, mas podemos avançar que será cerca de 4 semanas depois de a aveia começar a espigar, sendo as épocas mais prováveis de corte as seguintes:

Douro Superior e Terra Quente
10 a 30 de Maio

Áreas de Transição
25 de Maio a 15 de Junho

Terra Fria
10 a 30 de Junho.

PRODUÇÃO

A produção que se obtém depende das condições e da técnica de cultivo, mas se a técnica for a indicada, a não ser em casos de muito baixa fertilidade do solo ou de algum acidente de cultivo, é de esperar produções de 10 a 15 toneladas de feno por hectare. É uma alta produção, obtida num só corte.

Não é possível porém juntar só vantagens. Esta forragem assim obtida tem uma desvantagem que é a sua qualidade não ser elevada, especialmente no caso do feno por ter baixa quantidade de proteína. Porém é bem melhor que as palhas ou que ter os animais a fazer grandes percursos para pastarem pouco e de má qualidade nas épocas de escassez de pastagens.

Finalmente há que dizer que a utilização desta forragem e o seu interesse devem ser encarados em conjunto com os outros alimentos, como por exemplo as pastagens semeadas de sequeiro, assim como com as exigências dos animais, de forma a se tirar o melhor proveito e reduzir a desvantagem do seu baixo valor em proteína.

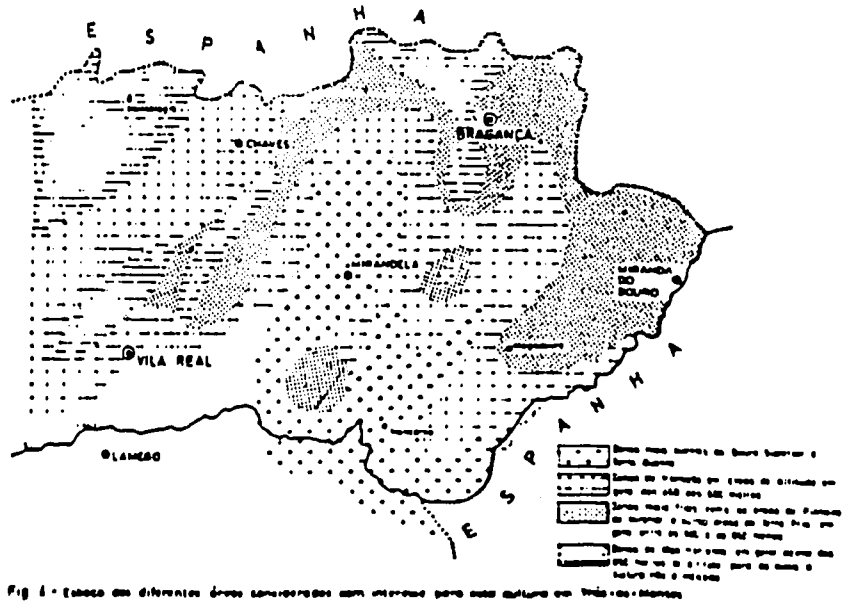


Fig. 4 - [illegible]

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Trás-os-Montes e Alto Douro
Vila Real, 1985