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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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University of California  
Hopland, California**

**June 27 - August 1, 1984**

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(Contract AID/NE-C-1701)

REPORT ON  
SHORT-TERM STAFF ASSIGNMENT  
AT THE  
UNIVERSIDADE DE EVORA  
EVORA, PORTUGAL

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## ACKNOWLEDGEMENTS

I wish to thank Vivian Rider and Purdue University for extending an invitation to me to visit the University of Evora and to the many hosts who made me feel welcome in Portugal. Thanks to Jose Ferreira and Francisco Garcia for their consideration and their extra time and effort during my visit; to Maria do Carmo Silveira for her special thoughtfulness to me and my wife; and to Pedro Silveira for his time and effort in my behalf. Thanks to Dr. Charles Rhykerd for helping us during our first days in Portugal.

I also wish to thank Evora University Reitor, Professor Ario Lobo Azevedo, for making my visit possible and Vice Reitor A. Santos, Jr., and Mariano Feio, Chief, Geoscience Department, for their hospitality and cooperation.

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## REPORT ON SHORT-TERM STAFF ASSIGNMENT

by

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### AREA OF CONSULTANCY

Soil fertility and plant nutrition of rain fed pastures of the Alentejo region of Portugal, University of Evora.

### SPECIFIC OBJECTIVES OF THE CONSULTANCY

To review research at the University of Evora on soil fertility of rain fed pastures; to observe fertilization practices and research in the Alentejo region of Portugal; to indicate techniques for measurement of forage production, botanical composition and chemical composition of the forage species as affected by soil fertility; to advise on soil and plant assay methods; to help plan future soil fertility research; and to present four seminars on nitrogen, phosphorus and sulfur fertilization and nutrient cycling.

### IDENTIFICATION OF PORTUGUESE COUNTERPARTS

I worked primarily with Jose Ferreira and Francisco Garcia. Both of these gentlemen teach soil fertility classes in the Department of Geoscience, University of Evora. I also had the opportunity

of consulting with a number of other people who are listed in the itinerary section of this report (Appendix A).

#### ACCOMPLISHMENTS WITH RESPECT TO OBJECTIVES

##### Review of Research on Soil Fertility of Rain Fed Pastures:

Virtually all of the soil fertility research in Portugal has been done on cultivated crops. I did see several farms and some experiments where natural rain fed pasture had been fertilized with superphosphate. These pastures appeared to be very productive, with carrying capacities of six to nine ewes per ha. However, information is lacking on which essential elements are deficient besides nitrogen and phosphorus. Little is known about how much or how often various fertilizers should be applied to obtain the greatest benefit.

An experiment on phosphorus-lime interactions on pasture seeded to subclover was begun in October 1983. It was very complex, requiring many hours of labor in the field for sample preparation and for laboratory analysis. The anticipated labor and laboratory facilities for this experiment did not materialize. Also a poor stand of clover was obtained due to insect damage and late seeding. Little data was collected from this study. This is the only research specifically on pasture fertilization that I saw at the University of Evora.

##### Observation of Fertilization and Research in the Alentejo Region

When cereals are grown in rotation with pasture, nitrogen and phosphorus-sulfur fertilizers are generally applied only to the cereals. The residual value of the fertilizer applied to cereals

which carries over to pasture has not been measured. We observed some pastures which were fertilized directly with phosphorus and sulfur, with apparently large responses by natural legumes. The value of these natural legumes relative to seeded ones such as sub-clover is not known.

#### Techniques for Measurement of Forage Production, Botanical Composition and Chemical Composition

Various techniques used under a wide variety of experimental conditions for measuring forage production and botanical composition were discussed. For example, forage production of subclover based pasture can only be estimated by clipping at ground level due to its prostrate growth. Botanical composition can be estimated by hand separation, point quadrat, step point or visual estimates depending on the detail required.

#### Soil and Plant Assay Methods

Various chemical analytical methods for soils and plants were reviewed, and suggestions were made for the time when a laboratory is available.

#### Planning Future Soil Fertility Research

Considerable time was spent in discussing what should be done in future studies. We tried to define specific single objectives suitable for graduate studies that could be reached with limited resources. This area is discussed further in the recommendation section of this report.

### Seminars

Four seminars were given which are outlined as follows:

First Seminar: "Determining Phosphorus Requirements for High Yielding Clover-based Pasture."

Single superphosphate contains three major elements; phosphorus, sulfur and calcium. The chemistry of each is different and thus their reaction with the soil and plants is different. For instance, sulfur can be leached from the soil much more easily than phosphorus or calcium. Thus, the residual effect of sulfur is usually much less than that of phosphorus.

Factors affecting responses to phosphorus: Plant growth must not be limited by other growth factors such as water, air or other mineral nutrients. Phosphorus is more available in warm soils than in cold ones. Legumes require a higher level of phosphorus than grasses and grasses require more than woody plants. Soil test phosphorus levels are inversely related to responses to phosphorus. The ability of a soil to absorb phosphorus into an unavailable form can increase the amount of applied phosphorus required to obtain maximum yields, and soils can differ greatly in their phosphorus absorption capacity.

Tests for phosphorus: Four classes of tests were discussed and examples of each were given--chemical soil tests, plant tissue analysis, pot tests and field tests. Examples of five field trials were given: phosphorus rate trials and response curves, residual value of phosphorus, relationship of soil tests to response, relationship of plant tissue analysis to response, and a phosphorus and sulfur grazing trial.

Second Seminar: "Why Sulfur May Become More Important for the Pastures of Portugal."

The following points were discussed in some detail: Greater amounts of sulfur will be required for high yielding pastures. The level of sulfur in superphosphate is being reduced in many places to lower shipping and application costs. Soil phosphorus levels tend to build with regular use of superphosphate, but sulfur levels do not. Sulfate-sulfur leaches from most soils. Deposition of sulfur from the atmosphere is probably very low in the Alentejo region of Portugal. Sulfur plays an important role in forage quality.

Examples of sulfur responses on California grasslands were given. Yield, chemical composition and species responses to sulfate and elemental sulfur fertilizers were illustrated with slides. The effect of sulfur on forage quality and animal production was reviewed.

Third Seminar: "Nitrogen Fixation by Annual Clovers Versus Nitrogen Fertilization."

Nitrogen fertilization trials on California rain fed grasslands was reviewed. In the 300 to 750 mm rainfall zone, we can usually get more than one kg of beef gain for each kg of nitrogen applied. If phosphorus and sulfur were applied with the nitrogen, we often obtained two kg beef/kg of nitrogen. Nitrogen should be applied before fall rains for best winter response. Leaching losses are high when heavy winter rains occur. Ammonium sulfate is recommended in preference to nitrate forms to minimize losses. Substantial losses can also occur through denitrification when soils are water-logged during winter. Responses to nitrogen are much less

when temperatures are less than 10° for extended periods. Applied nitrogen reduces the percentage of clover and the quality of spring and summer forage.

Subclover was compared with nitrogen applied to natural pasture. Subclover-grass produced forage yields equivalent to from 70 to greater than 180 kg N/ha, depending on the year and location. Protein levels were higher in forage from subclover in May than in natural pasture with 180 kg N/ha applied. Lambs gained more rapidly on subclover-grass pasture than on nitrogen fertilized ryegrass. Inoculation with strains of rhizobium specifically prepared for subclover has been essential in many areas of California. Adequate fertilization, usually with phosphorus and sulfur, coupled with grazing compatible with good seed production, is essential for permanent, productive subclover.

Fourth Seminar: "Cycling of Nitrogen, Phosphorus and Sulfur in Annual Pastures."

The nitrogen cycle in annual type rain fed pastures in the Mediterranean climate of California was discussed. Methods of quantifying the various above and below ground pools and flows were reviewed. The open nature of the cycle with its inputs and outflows was of special interest. We must have high annual inputs of nitrogen to have productive pastures. Phosphorus and sulfur cycles were compared with nitrogen. An example of nutrient transfer to the bed ground and shade, in addition to volatilization of urine nitrogen, indicated that if 66 kg N/ha were eaten by a herbivore that from 4 to 11 kg N would be available for plant growth on 90 percent of the pasture.

## IDENTIFICATION AND ANALYSIS OF PROBLEMS ENCOUNTERED

I felt that research objectives were so general that they did not help set experimental priorities. Jose Ferreira, Francisco Garcia and I discussed at length what factors were most limiting for pasture growth, what information was lacking and what the most researchable problems might be. We tried to break generalities into specifics. For example, rather than thinking in terms of pasture fertilization, we spoke of nitrogen, phosphorus, potassium, and sulfur, etc. We also tried to be as specific as possible with regards to the observations and measurements we expected to make in a given experiment.

Experiments must be planned that are compatible with resources available. For example, if more forage samples are taken than can be dried in available oven space, there is little point in taking them.

## RECOMMENDATIONS

### Research Objectives

Field experiments should be established with not more than one or two specific objectives which can be reached with the resources and time available. This is especially important when researching natural rain fed pasture systems in the Mediterranean environment. These pastures contain many plant species and the year-to-year variation is great. It is important not to try and reach too many objectives with the same experiment.

### Work Loads

Since instructors are expected to carry out research, University of Evora teaching loads and budgets should be arranged so that time and funds are available for research.

### Laboratory Requirements

Someone needs to be found who is specifically interested and skilled in soil and plant analysis. He should be compatible and work closely with researchers doing field trials. It is essential that laboratory facilities be made available to soil fertility research workers. With the present amount of manpower assigned to pasture soil fertility research, progress will be very slow even with the laboratory facilities available. One person should have the assignment of setting up and running the soil and plant analysis laboratory as their prime responsibility.

### Field Research

In making recommendations for field research, I am making the following assumptions, based upon what I learned during my stay in Portugal:

- nitrogen and phosphorus are the two most limiting factors for forage production;
- legumes should be used to supply the nitrogen;
- seeded stands of subclover have been short-lived and generally unsuccessful;
- natural legumes are quite abundant and will often be very productive given proper fertilization and other management;

- the responsiveness of various soils to potassium, sulfur, lime and micronutrients is not known; and
- the forage production potential of the poor soils of Portugal, when supplied with all of the required mineral elements, is not known.

The first two suggestions below could be the basis for two Ph.D. dissertations.

A series of exploratory trials should be established on poor soils with natural legumes in the pasture with the following treatments:

- 1) Complete - P,K,S,lime,micronutrients (Zn,B,Cu,Mo)
- 2) Complete - P
- 3) Complete - K
- 4) Complete - S
- 5) Complete - lime
- 6) Complete - micronutrients
- 7) Check

The objectives: To determine the productive potential of natural pasture with legumes present when major nutrients are applied and to determine which of these fertilizer elements contributes to yield.

This plot should be established with four replications in a randomized block at as many locations on natural pasture as time and resources permit. Note should be made of which legumes are present. Yields should be taken at the end of winter and spring. Soil samples should be taken from each site before fertilizers are spread. Available P, exchangeable cations and pH should be run on these soil samples.

Phosphorus rate trials should be established in a similar manner as the exploratory trial. I would suggest that at least five levels of phosphorus (0, 10, 20, 40 and 80 kg P/ha), and a blanket application of K and S be made on all treatments. A source of P, free of S, would be best if it can be obtained. If not, the rate of sulfur should be adjusted to a uniform level on each treatment. Four replications in a randomized block should be used with notes and yields determined as above.

If resources are available for long term studies, then larger trials with space for reapplication and residual P measurements should be established.

An evaluation of legumes growing on the annual grasslands of Portugal could be the subject of many graduate studies and should be of long term interest to some staff member. Such questions as: 1) which species are adapted to poorest shallow soils, and 2) how do they respond to an increase in soil fertility, need answers. Comparisons of natural legumes with each other and with imported subclover could be made. Someone needs to make sure that the imported strains of subclover are inoculated with effective strains of rhizobium that are competitive with resident bacteria in Portuguese soils.

Living conditions at Mitra were fine. I would just suggest that someone let visitors know that there is more flexibility in breakfast times than it first appears. It is possible to get an early breakfast when required. Also getting meal tickets the day previous or even a few hours ahead of eating time was often a hassle.

APPENDIX A

Itinerary

ITINERARY

June 27 - August 1, 1984

Wednesday, June 27

My wife and I left Ukiah, California at 4:30 a.m. via Hertz rental car. Left San Francisco at 8:30 a.m. and left New York at 7:20 p.m.

Thursday, June 28

Arrived in Lisbon at 7:10 a.m. Met by Francisco Garcia and Jose Ferreira, assistant professors, Geoscience Department, University of Evora.

We were taken to Evora where we met Maria do Carmo Silveira, who looked after our needs in Portugal. We were then shown our quarters at Mitra.

Met with Dr. Charles Rhykerd, of Purdue University, and his son, Charles, Jr.

Friday, June 29

A Holiday in Evora. We walked around Mitra looking at the soils, pastures, sheep and cattle. Visited with Dr. Rhykerd who was very helpful in orientation. In the evening, went to the fair and a bull fight.

Saturday, June 30

Visited with Dr. Rhykerd. Became acquainted with Evora.

Monday, July 2

Taken to Evora by Jose Ferreira and Francisco Garcia. Met Dr. Herbert Albrecht, who represents the German government and is responsible for their aid program.

Visited a field experiment near Evora. They had planted sub-clover (none, medium and high seeding rates) with split plot treatments of P and lime. It was too large for their limited resources and they were quite discouraged.

Went to a farm 25 Km west of Evora where we saw natural pasture fertilized with 150 Kg superphosphate/ha/year for three years. It was very productive. Subclover plantings do not persist more than three years.

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Tuesday, July 3

Spent some time in the library at Mitra. (It needs organization.)

Met with Dr. Herbert Albrecht and reviewed his program.  
Met with Prof. Ario Lobo Azevedo, Reitor at the University of Evora. Met Mariano Feio, Chief, Geoscience Department and Jorge Grilo, agricultural engineer, soil survey and classification.

Wednesday, July 4

Went with Francisco Garcia and Jose Ferreira to see some of the best and worst soils in Portugal. We went south from Evora and saw wheat, barley, sunflower rotation on the best soils and oat pasture rotation on those less productive. There is a hard pan on many soils which results in a perched water table in winter which results in anaerobic soils and the death of much cereal in winter.

Went via Beja, Mertola and crossed the Rio Guadiana. Stopped at Vale Formoso Experimental Station and observed a sheep stocking rate trial.

Thursday, July 5

Francisco Garcia took me to southeast of Evora, east of Moura near the Spanish border. Even the poorest soil had many annual legumes. We had lunch with Francisco's father, a farmer who lives at Moura. I learned many particulars about their farming operation.

Friday, July 6

Jose and Francisco showed me farms west and northeast of Evora.

Saturday, July 7

Shopping in Evora. Studied Edw. Carter's report and Francisco and Jose's project proposal. Also an N fixation study by Luis Manual Cardoso Vieira Coelho.

Monday, July 9

Jose Ferreira and Jorge Grilo took my wife and I northwest of Evora to Tramagal, then down the Rio Tejo. We saw forestry, orchards and many different aspects of irrigated and rain fed agriculture.

Tuesday, July 10

A.M. with Jose Ferreira, Francisco Garcia and Jorge Grilo consulting on P studies, soil available P, PS Mo interactions, experimental designs, etc.

P.M. with Mariano Feio, Francisco and Jose reviewing subclover establishment and management practices. Also brush control, use of the rangeland stump jump drill and California agriculture, in general.

Wednesday, July 11

Spent the day with Jose and Francisco defining specific objectives and the experimental designs to meet those objectives.

Thursday, July 12

Jose took me to Elvas. We spent a very interesting day visiting with David Crespo reviewing his program. Also met Manual Barradas, Director of the Plant Improvement Station at Elvas, and Dontel Serafim, Deputy Director of the Institute of National Investigations in Agriculture.

Friday, July 13

Met briefly with Jose and Francisco. Spent most of the day studying papers, making notes of previous activities and preparing seminars.

Saturday, July 14

Spent the day looking at historical landmarks in Evora Monte, Estremos and Vila Vicosa.

Monday, July 16

One bald tire went flat on the way to Evora. Visited with Pedro Silveira regarding history of subclover in Portugal. It does not persist more than about three years and they do not know why. Subclover and/or natural clovers, plus superphosphate, can increase carrying capacity from 1 to 2 ewes/ha to 6 to 9 ha.

Tuesday, July 17

Met Jaime Reis, history professor from Lisbon. He has written a history of superphosphate in Portugal. I talked to an English class preparing students to go abroad. Pedro showed me some of the trials (stock rate, for instance) at Mitra.

Wednesday, July 18

Pedro took me to University Farms west of Beja. Talked with Afonso Almeida regarding his forage sampling methods. He is looking at forage quality on various soils.

Thursday, July 19

Met with Maria do Rosario Oliveira and reviewed her Ph.D. research work on the growth patterns of ryegrass tall fescue, alfalfa, white clover and subclover. Next, Mario Carvalho showed me his work on N fertilization of wheat. Also met with Jose and Francisco.

Friday, July 20

Pedro showed me the irrigated farming on the University farms called Outeiro, just west of Ferreira do Alentejo, and the Darveira farm. Next, we went to Oeiras (suburb west of Lisbon) to see Jose de Almeida Alves, Eng. Agronomo, Investigador Principal, Instituto National de Investigacao Agraria Coordenado do PROCALFER. He showed me scatter diagrams of relationships of relative yields and four soil tests for P: Riehm, Bray 1, Bray 2 and Olsen. These were done for cereals, hay and several other crops, but not for pasture. These comparisons of the four P extraction methods apparently have not been published. I encouraged him to do so. I was impressed with his work.

Saturday, July 21

Visited Spain, from Badajos south to San Fernando.

Monday, July 23

Spent the day with Jose and Francisco working out details of P x lime and P rate trials for natural pastures.

Tuesday, July 24

Gave seminar on determining P requirements for pastures and prepared for next seminar.

Wednesday, July 25

Gave seminar on sulfur. Met with Vice-Reitor A. Santos, Jr. and his student Hans Gunther Bless who is working on soil drainage. Reported to Reitor Azevedo. Had dinner at Carmo and Pedro Silveira's home. Prof. Albuquerque was also there.

Thursday, July 26

Gave seminar on nitrogen fixation. Visited with Manuel Sobral, Chief of the Project of Drainage and Soil Conservation of the Alentejo, and O. A. Sims, Soil Conservation Management Planner, FAO. They explained the poor drainage and erosion problems and what they were trying to do about it.

Friday, July 27

Gave seminar on nitrogen, phosphorus and sulfur cycling. Met with Pedro to pick up publications and learn what he would like to see on his proposed visit to California.

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Saturday, July 28

Packed, drove to Lisbon. Worked on end-of-tour report.

Monday, July 30

Worked on report and took it to the USAID office at the American Embassy, Lisbon.

Tuesday, July 31

Jose Ferreira and I went to the USAID/Lisbon office to report to Jose Luis Pinheiro. I reviewed a draft copy of my report and sent it to Mrs. Rider at Purdue.

Wednesday, August 1

Drove to Evora and checked out with Carmo Silveira.