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STAMMEL

REPORT
ON
LIMING ACID SOILS TO SUPPORT PRODUCTION AND SOUND AGRICULTURE

BY

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CONSULTANT IPB/UW GRADUATE EDUCATION PROJECT

DEPARTMENT OF SOILS

UNIVERSITY OF RIO GRANDE DO SUL

BRAZIL

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COUNTERPARTS: PROF. OETIT KOSWARA

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I wish to express my sincere appreciation to Dr. John T. Murdock for his confidence in inviting me for this consultation in Indonesia as well as to the USAID Graduate Education Project, IPB Bogor, for the financial support. I also thank Dr. Murdock and wife for their permanent attention during my stay in that country.

I also wish to extend appreciation to Drs. Oetit Koswara, Fred Rumawas, and Lutfi Nasoetion, as well as to all members of the Soils Department for the support they gave me.

It was my objective as consultant, to transmit my experience about a rural development program executed in southern Brazil in which I was a participant. It is my hope to have contributed in some way to researchers and policy-makers in their discussions of rural development programs presently going on in Indonesia.

TABLE OF CONTENTS

Objective of the Consultancy.....1

Introduction.....1

Present Situtation.....3

Visits to Sumatra.....5

Suggestions.....6

Annex I.....9

Annex II.....13

Program Developed in Australia and Hawaii.....16

Annex III.....18

Annex IV.....20

OBJECTIVE OF THE CONSULTANCY

To make research workers and policy-makers more sensitive to the imperative need for liming acid soils to support a productive and sound system of agriculture.

INTRODUCTION

The concern for efficient and rational mobilization of natural resources for production of food for internal consumption, biomass for energy, and agricultural products for export is universal. However, this concern is greater in lesser developed countries which normally have a high percentage of the population in rural areas and a low level of employment opportunities in the industrial sector. In this situation it is necessary to maintain large numbers of farmers in the rural areas. This is possible only if maximum rational use of the natural resources is practiced through the use of adequate technologies. The stability of the rural population depends directly on the high productivity and profitability of farmlands and the creation of jobs in rural areas through the development of agro-industry. In order to reach this objective it is necessary to promote agricultural research and education, invest heavily in rural credit, and create an efficient system of rural extension.

The development which has occurred in southern Brazil is a good example of the difficulty of development in rural areas of a lesser developed region. In the decade of the sixties this region was the target of an intense out-migration of young farmers to other agricultural regions of the country or preferably to large cities, leaving behind older, tired farmers and soils impoverished by continuous cultivation, inadequate protection against erosion, and failure to replace nutrients used by crops. The region partially lost its most important resources, productive people, and land. The recuperation of this region was made through an interinstitutional program (university, Secretariat of Agriculture, Rural Extension, banks, and local leaders) which introduced adequate technology and supervised rural credit. The program was principally made up of activities to recuperate the fertility of impoverished soils by fertilization and liming, introduction of quality seed, and the use of appropriate cultural practices for each crop. This brought new perspective to the agriculture of the region. It is obvious that the use of investment credit was necessary to accomplish this work.

The recuperation of soils, impoverished by years of misuse or by the process of their genesis, is expensive and would be impossible to cover by the use of annual credit. The strategy used in this project also permitted the opening of new areas whose soils were considered inappropriate for agriculture because of low productivity. In these cases, the low levels of production were the consequence of the high degree of weathering of the soils (Oxisols and Ultisols). Normally these soils are poor in nutrients and rich in exchangable aluminum; in addition, they are microbiologically poor. The use of these marginal areas for agriculture made the expansion of soybean production in Brazil possible. Brazil expanded its limited production to become the second largest producer of soybeans in the world in less than ten years.

Oxisols and Ultisols are frequently found in humid tropical and subtropical regions. Indonesia is no exception to this general situation and at least an important part of Sumatra, which we had an opportunity to visit, is represented by highly weathered soils which had been covered by tropical rain forests. The utilization of these soils for transmigration projects appears to be an objective of the government of Indonesia. The correction of the acidity of these soils is fundamental to the construction and reconstruction of their fertility. The productivity of the majority of the soils located in the humid tropics and subtropics of the world will depend, to a greater or lesser degree, on this practice. The smaller the rural properties, the greater is the need for fertile soils. Often the productivity of these soils is also limited by excessive acidity.

The success of the program developed in southern Brazil can be principally attributed to the objectivity with which it was conducted. In the field of agricultural research, the activities were practical. They left behind the traditional scientific speculation, so frequent in developing countries, behind and moved rapidly from results obtained to recommendations. Training of professors, researchers, extension agents, financial agents, establishing uniform criteria for recommendations and cultural practice (soils, plant science, and animal science) among various agencies, organization of the flow of inputs (lime, fertilizer, seeds, and pesticides) and products, and the provision of investment credit were fundamental to the initiation and rapid expansion of the program.

It should also be pointed out that liming, rational fertilization, and oriented agricultural credit were the principal factors responsible for the

immediate increase in production of traditional crops of the region. This, along with the introduction of new varieties and cultural practices, and the opening of new areas previously considered unsuitable for agriculture, awakened the enthusiasm of farmers and local leaders.

Only fertile soils can give stability to agriculture and sustain the dignity of the normally large families of the small farmer. The fertility of the soil is also important to the diversification of crops which permits an agricultural model with a high degree of independence so necessary in developing countries.

It is possible to affirm that programs of the nature referred to above can be developed in other tropical and subtropical regions, respecting, logically, the peculiarities of the region.

The principal areas of research developed in the area of soils to give technological support to rural extensionists in the program were as follows:

1. Reconnaissance of the principal groups of soils of the region to determine their production potential and suitability for agriculture.
2. A study of methods for determining lime requirements.
3. Correlation studies of methods to determine available P & K.
4. The plant availability of micronutrients as a function of liming.
5. Calibration studies for soil testing.
6. Degree of mineralization of organic matter as a function of liming.
7. Symbiotic fixation of nitrogen.
8. Composition, evaluation, and annual re-evaluation of tables of recommendations for lime and fertilizers among research agencies.
9. Studies for erosion control.
10. Non"academic" economic studies.

PRESENT SITUATION

Following are comments about the situation encountered in some regions of Indonesia visited, in relation to the objective of our stay with the Institut Pertanian Bogor (IPB). These comments are based on our professional experience, impressions from visits to transmigration projects and experimental stations in West and South Sumatra, and on contacts with staff and technicians of IPB and the Soil Research Institute in Bogor. The short term of our visit and the lack of complete understanding could result in errors of judgment of the local situation.

1. Soils:

Large areas of the soils on Sumatra are made up of Oxisols and Ultisols whose productive capacity, other than for tropical forests, is dependent on the neutralization of acidity and on fertilization, principally with phosphate and nitrogen. Research in progress in the Experiment Stations of IPB at Sitiung I and II evidence this fact. A good indicator of this problem is the low density of active farmers in the area; this is true even on Java where soil conditions are similar to those on Sumatra.

2. Research:

   a. The number of IPB professors and scientists from other agencies involved in soils research is satisfactory.

   b. The facilities for research in soils (field and laboratory) are excellent.

   c. Field research in progress is adequate to support the development of tables of recommendations for lime and fertilizer for immediate and future use. As new information is obtained these recommendations should be adjusted.

3. Rural Extension:

Unfortunately it was not possible to obtain sufficient information regarding the practice of rural extension in Indonesia. What appeared to be true was a certain separation between research and extension. This must result in limited application of new technology in the area of production.

4. Lime and Fertilizer Recommendations:

Recommendations for lime and fertilizer are very general and evaluation at the farm level is not practical. Fertilizer is primarily used for irrigated rice. The use of soil tests to make fertilizer recommendations is a practice which is seldom used, and the analytical methods and criteria for recommendations are not uniform among different agencies. This must reduce the efficiency of the Rural Extension Service.

5. Use of Inputs (Lime and Fertilizer):

   a. Lime: In spite of the cultivation of extensive areas of extremely acid soils, the use of agricultural lime in Indonesia is very limited. The probable reasons may be:

1) Relatively recent use of these soils (transmigration areas) for food production.
2) Limited availability of agricultural limestone.
3) Difficulty in transport.
4) Introduction and adaption of the philosophy of "low inputs" which has been spread in underdeveloped countries (we do not understand the intentions of this philosophy) regardless of their predominant farming system.

b. Fertilizers: With the exception of irrigated rice, little fertilizer is used. The reasons for this must be similar to those cited for liming.

6. Availability of Limestone:
Limestone is abundant on Sumatra and Java and mining should be easy. According to the information received, calcitic limestone predominates.

7. Production of Agricultural Limestone:
The production of agricultural limestone is limited and can be characterized as experimental production by cement plants. The exploration of this industrial sector may be encouraged in West Sumatra because of the great interest demonstrated by the local government (Governor) in promoting this activity.

VISITS TO SOUTH AND WEST SUMATRA

The visits to transmigration projects in West Sumatra Sitiung I and II, South Sumatra (Upang Delta and the Benchmark Soils Project in Lampong), provided a good idea of the governmental intent to provide a better distribution of the rural population in the country and to increase the production of food.

As an example, the government of West Sumatra is mobilizing a team of specialists with the mission of organizing the agro-industrial infrastructure, thus providing conditions for rapid development of primary sectors.

In the three transmigration projects visited we found experimental stations of IPB giving technological support to farmers established there. In relation to the Benchmark Soils Project, which is also installed in Central Brazil, there are doubts as to the effectiveness of results for the regions of small farms whose productivity is very hetrogenious, independent of climate and soil. The recommendations for fertilization are uniform for all locations and are made on the basis of soil type, regardless of the farmer and his farming systems. In addition, these recommendations are oriented by the philosophy of "low inputs" with which we do not agree, especially as it relates to small, subsistence farmers.

SUGGESTIONS

Based on information obtained from IPB, observations from visits to Sumatra, and professional experience on the subject, we take the liberty to make some suggestions. The purpose of these suggestions is to collaborate in a program for the intensive utilization of acid soils in Indonesia.

1. Research

   a. Analyze the results of research already existing and immediately make tables of recommendations for fertilizers, lime, and other cultural practices for a region or problem area.

   b. In parallel, initiate studies to select methods for determining lime requirements involving the principal problem soils.

   c. Selection of methods for determining P and K and some micronutrient if necessary (correlation studies).

   d. Calibrate soil tests, principally for P and K (give particular attention to soil texture).

   e. Study the residual effect of lime and P, involving a sequence of crops (long-term studies).

   f. Study erosion and soil conservation (principally crop rotations efficient in soil conservation).

   g. Studies relating to the efficiency of bulk limestone storage. This study appears to be important for Indonesia. Because of high rainfall, it is possible that considerable loss of limestone (piled outside) might occur.

   h. Establish uniform criteria for the evaluation of soil fertility and recommendations for lime and fertilizer among research agencies (at least at the Provincial level). The lack of uniformity of these criteria, besides being unjustifiable, will result in a lack of confidence of extension agents in research and of the farmers in the agents. This lack of confidence would damage the program of development.

2. Teaching:

   Whenever possible involve a good number of graduate students in the research which suggests the program, as well as in the training of extensionists, financial agents, and local leaders. This involvement is considered important because it diminishes the distance which generally exists between research and extension.

3. Extension:

   a. Training and retraining of extension agents (preferably in the region where they work) should be carried out by researchers who transmit new technologies and who listen to suggestions for new research. Observation: Harmony between researchers and extension agents was of major importance in the development of the program in southern Brazil.

   b. Training of farmer leaders to adopt new technologies should be done by extension agents.

   c. A program should be initiated in a region in which there is a probability of a high level of response to inputs and with a small number of farmers. This will facilitate, especially in the beginning, program modifications, adjustment of the agents to the program, and control of the program.

4. Other Technical Aspects:

   a. Carry out in an intermediate time span, an inventory of lime reserves in Indonesia, or at least in the important agricultural areas, determining the amount and the physical and chemical characteristics of the limestone.

   b. Invite a consultant in relation to production (equipment), flow of production, and distribution of limestone for the problem regions. In southern Brazil excellent assistance was provided by a technician from Volcan Materials, Waukesha, Wisconsin, USA. This item is considered extremely important because the availability of limestone is essential to the expansion of the program.

   c. A visit of one or more scientists of IPB to Southern Brazil is recommended. On-site observation of the system of agriculture established, the capacity of storage installed (agricultural products and inputs), flow of production of inputs, agricultural research in progress should furnish important information to Indonesian officials and to the agencies involved in primary production.

OBSERVATION

We are of the opinion that the leadership of programs for rural development should be centered in universities or institutes of higher education. These institutions normally have continuing research programs and the critical means of staff with high qualifications to carry out the program. In addition, they are responsible for the education of scientists who will have the task of development of agriculture in the country.

ANNEX I

EFFECTIVE USE OF RESOURCES

A Program for Improving the Productivity of Soils in Southern Brazil

A. Soils

1. Basically, any program for improving agricultural production should begin with a survey of soils. The objective of the survey should be to determine the physical and chemical characteristics and the geographic boundaries of the soils, thus, the potential for increased agricultural production.
2. Determination must be made, through observation and chemical analysis of the soil, of the limiting factors relative to lime and fertilizer requirements.
3. How was this done in Rio Grande do Sul, Southern Brazil? Brazilian agronomists:
   a. Initiated a post graduate program in UFRGS;
   b. Used the existing soil survey for agricultural planning-selection of the most important soils;
   c. "Cleaned out the desk drawers" where experimental results were stored away, classified them, and used them;
   d. Carried out laboratory and greenhouse studies to correlate soil testing methods (principally P) and established methods for quantitative determination of lime needs;
   e. Initiated a soil testing program, and used "good sense" (judgment) when necessary for resolving problems related to the program;

f. Were not afraid to make recommendations with the small amount of existing data, combined with good judgment.

Table 1. The Fertility Level of Soils in RGS at the Beginning of the Soil Recuperation Program (based on 53.00 samples).

Lime Needed		Phosphorus		Potash		Org. Matter	
Tons/ha	% of samples	Level	% of samples	Level	% of samples	Level	% of samples
0 - 4	60	VL	78	VL	3	VL	60
4 - 8	23	L	17	L	12	L	25
8 - 12	12	M	3	M	15	M	10
12	5	Hi	2	Hi	70	Hi	5

VL = Very Low
L = Low
M = Medium
Hi = High

B. Water and Climate

1. Depending on the availability of water, it is possible to use irrigated crops in production programs, giving a greater guarantee of high production to the producer and to the market. In most cases, however, it is necessary to use upland crops which require varied cropping sequences to take advantage of seasonal changes.
2. The time of planting and harvesting of crops in different crop sequences are first related to important climatic factors of the region under consideration. But cropping sequence should also give consideration to soil relief. A good crop sequence (preferably including a legume crop) is fundamental to the best use of the soils of a region. The cropping sequence appropriate for climatic conditions of a region and for soil conservation, determines the compatability of agriculture and the environment.
3. What was done in Rio Grande do Sul?
   a. Existing meteorological data was used in the study of new introductions (species and varieties);

b. Through field experiments, the best times for planting and harvesting of various crops was determined in order to design the best cropping sequence for the region.

Table 2. Farmer's Average Yields of Early and Late-Planted Soybeans Grown in Infertile or Fertilized Soils in Santa Rosa (RS), 1968-1969.

Variety	Soil Fertility Treatment	Planting Data	Yield (kg/ha)	No. of Fields
Santa Rosa	followed soil test	Mid season	2 166	17
Santa Rosa	followed soil test	Late	1 144	13
Santa Rosa	none	Mid season	871	11
Majos	followed soil test	Early	1 343	5
Majos	followed soil test	Late	1 198	7
Majos	none	Mid season	440	2

C. Crops

1. It is well known that in poor acid soils the variety of crops which can be expected to produce reasonable yields is greatly reduced. The continuous use of crops which have the capacity to extract nutrients without requiring replacement, leaves behind after some years, unproductive "skeletons" of soils. Many countries have had or will have this experience of impoverishment of their soils. This is one of the principal motives for migration from rural areas to the city. Fertile soils (natural or fertilized) permit the establishment and production of a large number of crops and/or varieties, providing the farmer and the country with greater options for agricultural production.
2. The correction of infertile acid soils (lime and fertilizers) greatly increases the potential for crop production and makes it possible to use a larger number of species in crop rotations which are so desirable in modern agriculture. Practically, to correct soils is to return to them that which they had when they were young.

3. What was done in RGS?

   a. The program for improving the fertility of soils in RGS made it possible to increase the introduction of new species and varieties of crops from other parts of the world. Today it is possible to see both field and fruit crops growing in RGS which previously were grown only on the fertile soils of Argentina and Europe;

   b. The program also greatly influenced many geneticists to modify their criteria, developing new varieties which have higher growth requirements but are more productive. Convincing them was difficult but worthwhile;

   c. Today combinations of crop rotations in RGS are varied. This gives greater options in agriculture and greater independence to the country;

   d. Correction of soil fertility (lime and fertilizer) made it possible to introduce the wheat/soybean sequence important to the rapid increase in soybean production in Brazil.

ANNEX II

A PROGRAM FOR IMPROVING THE PRODUCTIVITY OF SOILS IN SOUTHERN BRAZIL

A. What was the program?

It was a major rural extension program whose objective was to take new technology for agricultural production directly to the farmer, with special attention to the correction of soil acidity and soil fertility and the improvement of soil and crop management practices.

This program was made possible by the integration of activities of various institutions (research, extension, farmer groups, cooperatives, banks, and local government). The leadership was provided by the university which gave technological support, including recommendations for fertilizers and limestone, based on a good program of soil testing.

Table 1. Evolution of the Program for Improving the Productivity of Soils.

Year	Number of Counties	Number of Farmers	Ha Recuperated	Lime (t) Applied	Fert. (t) Applied	Investment Cr $
66	1	14	16	63	3	3,700
67	4	91	100	334	19	22,500
68	43	2144	4603	17281	1783	1,500,000
69	85	3074	11663	43140	7140	3,500,000
Total	85	5323	16382	60818	8945	5,026,200

B. What were the requirements for executing the program?

1. Extension agents appropriately trained to attend the needs of the farmer.
2. A network of banks to finance the recommended practices with short-term and long-term (4-5 year) credit at favorable rates.

3. Cooperatives of rural associations, to market the inputs and products.
4. Soils with agricultural potential.
5. Crop and livestock system of economic importance.
6. Interest of authorities, leaders, technicians, and the community in the program.
7. Organization of the community and farm leaders.
8. Ability to abtain inputs such as limestone, fertilizer, seed, etc.

Items 1, 2, and 8 were essential to the success of the program.

C. How was the Program Planned and Executed?

1. By training extension agents, bringing them up to date on new technology and establishing uniform criteria for program activities. Responsibility: university and research centers.
2. By mobilization of the community and establishing the program. The mobilization of the community (administrators and farm leaders) was achieved by convincing them of the potential of the region and the economic importance of the program to the county, the state, and the nation. Responsibility: local technical agents who had been trained for the program.

Table 2. Average Production Levels Attained in Various Experiments Executed by the University.

Crops	Treatments		
	Control	Fert. only	Fert. and lime
	.....kg/ha.....		
Soybeans	850	2500	3200
Wheat	800	1500	2200
Corn	1800	4190	6560

3. By advertising the program. Announcement and description of the program was carried out through radio, brochure, the church, and other community organizations. Responsibility: rural extension agents.

4. By training the farmers. In this case the farmers were called together in their communities by the rural extension agents and informed of the objectives and advantages of the program. They were also told how to participate in the program and received instructions on how to take soil samples to be sent to the laboratory. At this time practical demonstrations were given by the extension agent.
5. By testing the soils. The soil testing program was initiated by the university; later, laboratories of other agencies also participated (uniform methods were used by all agencies).
6. By recommendations for lime and fertilizers. The recommendations were made on the basis of soil tests at the laboratories and were normally sent to the extension office which forwarded copies of the recommendations to the farmer and to the local bank.
7. By determining the production inputs needed. On the basis of recommendations and the area of soils to be recuperated, it was possible to make a reasonable estimate of the limestone, fertilizers, seed, pesticides, etc., needed. These estimates were very important because they provided orientation for developing the infrastructure needed for the program. Responsibility: rural extension agents.
8. By establishing the credit needed. The need for credit was also based on the requirements cited above.
9. By establishing demonstration areas. The best way to convince the farmer is through good demonstration areas on the property of the farmer and not on experimental fields. Responsibility: rural extension agents oriented by the researcher.

We are of the opinion programs of this nature, in addition to benefiting the farmer, provide a means for integrating institutions related to agricultural production and puts the university (professors and students) in contact with the productive sector in the nation.

PROGRAM DEVELOPED IN AUSTRALIA AND HAWAII

AUSTRALIA

1. CSIRO - Division of Tropical Crops and Pastures
The Conningham Laboratory
Brisbane, Queensland

The regions addressed by the programs of the Division of Tropical Crops and Pastures of CSIRO are very different from those visited in Indonesia, principally in relation to soils, climate, and agricultural activities. The soils are for the most part slightly acid to neutral, with possible occurrance of Mn toxicity. The programs of research in the area of fertility are highly sophisticated and are concentrated principally in the efficiency of phosphate fertilizer and recycling of nutrients in areas of cultivated pastures. The climate is seasonal and the principal agricultural activity is beef cattle production. Based on the observation above, it is doubtful that short-term training of personnel in soil fertility in this Division of CSIRO would be useful. We recommend, however, that contacts with the section of Plant Introduction of this Division be made regarding exchange of material, especially for cover crops and forage plants. This section has some excellent material under observation. The program developed for our visit is in Annex III.

2. CSIRO - Division of Plant Industry
Canberra, D.C. Canberra

The program followed at the CSIRO headquarters was informal but useful. We made contacts with soil scientists (soil fertility), Dr. Murray L. Bromfield and Mr. John Lipsett. Dr. Bromfield concentrated his activities in the study of factors limiting the production of crops, especially Mn toxicity and the acidification of soils by the addition of fertilizers, and in phosphate fertilization. In both cases the techniques used are simple and objective, keeping the farmer in mind. Even though the agricultural activities are

principally livestock production (beef and dairy) with temperate to sub-tropical crops, we suggest the possiblity of short-term training, especially in the objective philosophy of research of the staff.

HAWAII - USA

The University of Hawaii/AID NifTAL Project
Maui, Hawaii

Due to our short stay in Hawaii it was not possible to contact local soil scientists. Our visit was limited to the NifTAL Project. It was interesting to contact scientists of the project and to know more about their principal activities. In addition to the scientific objectives of the project (symbiotic N fixation), they are also working to develop energy forests with different species of legumes. The preliminary results of these studies look promising and scientific exchange in this area could be useful in the future.

ANNEX III

VISITOR PROGRAM

Dr. Josè Jermano Stammel
Dr. Joào Ruy Jardin Freire
Faculty of Agronomy, Federal University of Rio Grande do Sul, Porto Alegre, R.S. Brazil.

Tuesday, July 6, 1982

During the morning Dr. Stammel and Dr. Freire will join discussions with Mr. Ritchie and Mr. Abba who are also visiting Cunningham Lab.

P.M. Program for Dr. Stammel

1:30 pm Dr. F. W. Smith (Leader, Plant Nutrition)
- comparative nutrition of pasture species; basic nutritions of summer cropping species; diagnosis of nutrient disorders; availability of soil phosphate.

2:00 Dr. B. A. Keating (Plant Nutritionsist)
- nutrition and growth of legumes on clay soils; effect of pH on legume growth and nutrition.

3:15 Dr. P. C. Kerridge (Plant Nutritionist)
- maintenance fertilization of grass-legume pastures; studies with rock phosphate.

P.M. Program for Dr. Freire

1:30 pm Dr. R. A. Date (Leader, Legume Bacteriology)
- ecology of *Rhizobium* for tropical forage legumes; effects of physical environment on nodulation and nitrogen fixation in tropical legumes.

and

Dr. H. V. A. Bushby (Legume Bacteriologist)
- ecology of *Rhizobium* for tropical grain legumes; factors related to nodule formation and function.

3:30 Dr. W. Jehne (Division of Soils) - Soil microbiologist.

W. Elich
Technical Information Officer
July 5, 1982

Mr. W. Ritchie and Mr. A. A. Abba

Tuesday, July 6, 1982

Mr. Ritchie and Mr. Abba are visiting several agricultural research institutions in Australia and they will visit the Cunningham Laboratory on the morning of Tuesday, July 6. Mr. Ritchie and Mr. Abba are associated with the Kano State Agricultural Development Project based in Northern Nigeria. This region has a tropical monsoonal climate with an annual rainfall ranging from 600 to 1000 mm with light textured soils of low fertility.

Their interests are: tropical pastures, new species of grasses and legumes, pasture establishment, management, and productivity.

9:00 am Mr. R. J. Williams (Leader, Plant Introduction and General Resources)
- plant introduction for the sub-tropics; plant geography and adaptation; legume taxonomy information retrieval systems.

and/or

Mr. R. W. Strickland (Plant Introductionist)
- differentiation, environmental adaptation and agronomy of introduced forage plants; toxicity studies with Cassia, Crotalaria, Indigofera, and Tephrosia.

9:45 Dr. R. K. Jones (Plant Nutritionist)
- plant nutritional aspects of ley farming systems in the semi-arid tropics; role of endomycorrhizae in the nutrition of tropical crops and pastures; rock phosphate and biosuper as alterntive P fertilizers.

10:30 Tea/Coffee

11:00 Dr. L. 't Mannetje (Pasture Agronomist)
- management of sown pastures, especially responses to stocking rate and fertilizer; ecology of sown pastures; species evaluation; taxonomy of Stylosanthes.

11:45 Dr. J. C. Tothill (Pasture Ecologist)
- ecology and productivity of improved and native pastures on spear grass lands.

T. W. Elich

Technical Information Officer

June 30, 1982

ANNEX IV

WORK SCHEDULE

982

une 4 - Left Porto Alegre to Rio de Janeiro.

- Left Rio de Janeiro to Miami/Los Angeles.

5 - Left Los Angeles to Singapore.

7 - Arrival in Singapore at 1:00 a.m. (lost one day by time difference). Left Singapore at 10:00 a.m. to Jakarta. Arrived Jakarta at 2:00 p.m.

8 - Contact with counterpart Dr. Oetit Koswara and arrangements at US Embassy in Jakarta. Meeting with Dr. Robert Seeling, manager of AID Programs in Indonesia.

9 - Trip by plane to Padang, on the island of West Sumatra. Visit a Estacao Experimental Keban Percolian IPB and from there by jeep 270 km to East Sumatra - Experimental Station of Sitiung II - IPB.

10 - Visit to experiments established at Experimental Stations of Sitiung I and Sitiung II and Two Transmigration Projects in the same area.

11 - Trip back to Padang. Meeting with the Governor of West Sumatra, his assistants, and other local authorities. Exchange of ideas in the relation to governmental project for lime production in the province.

12 - Trip by plane to Jakarta and from the airport by another flight to Palembang at South Sumatra.

13 - Visit to Upang Delta Transmigration Project and experiments established at IPB Experiment Station.

14 - IPB - Bogor - Meeting with the staff of the Department of Soils and presentation of our program.

15 - Selection of literature and slides on the Project for Improvement of Soil Fertility in Rio Grande do Sul, Brazil.

16 - Visit to IPB Main Campus, laboratories of the Department of Soils for research, teaching and routine.

17-18 - Informal presentation to staff of the Department of Soils on the problems related to liming acid soils with high Al and Mn in southern Brazil. Experimental work performed and underway. Lime quality control (PRNT) and trading. Fertilizer and liming recommendation in Rio Grande do Sul and its origin.

19 - Visit to Gunung Gedeh - mountain agriculture, mainly tea. Horticulture and paddy rice.

21 - Informal discussion with staff of Department of Soils on the use of agriculture lime.

22 - Seminar to university staff and researchers from other institutions (Summary in Annex).

23 - Holiday.

24 - Informal discussion with members of the Soils Department about a soil testing program in South Brazil, a visit at Campus IPB Darmaga.

25 - Visit to the Soil Research Center, Ministry of Agriculture, Bogor.

26 - Seminar to university staff and administrators (Summary in Annex).

29-30 - Trip to Lampung - South Sumatra - Visit to experiment station of the Benchmark Project.

July 1 - Visit to the Botanic Garden in Bogor.

3 - Left Bogor/Jakarta to Denpassar (Bali).

4 - Left Denpassar (Bali) to Sidney, Australia.

5-7 - Visit to CSIRO at Brisbane (Queensland).

7 - Left Brisbane to Caberra.

8 - Visist to CSIRO at Caberra.
Left Caberra to Sidney.

10 - Left Sidney to Honolulu (Hawaii).

12 - Visit to NifTAL - University of Hawaii/AID Project at Maui.

13 - Left Honolulu to Los Angeles.

15 - Arrived Porto Alegre, Brazil.