PN-AAZ-817

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CENTRO AGRONOMICO TROPICAL
DE INVESTIGACION Y ENSEÑANZA

Turrialba - Costa Rica - Teléfonos: 56-64-31 - 56-01-69 - Telex: 8005 CATIE C. R. - Cable: CATIE Turrialba

Sept. 10, 1987

Dr. John Malcolm
Office of the Science Advisor
AID
Washington, D.C., 20523

Dear John:

After talking with you at the ASA meetings in New Orleans, it became clear to me that you were not receiving the interim progress reports of AID-SCI Project 936-5442 , Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils, although I was depositing five copies in the ROCAP office in San Jose. Apparently, nowhere in the project paper does it provide that ROCAP forward a copy of the Interim Progress Reports to Washington. I therefore tried to send you copies of the first two interim progress reports in January, 1987 with Dr. James Walker who was here for our Board of Directors meeting; but they do not seem to have reached you. When I spoke to your secretary in June, there was no record of such reports. In any case, I am now sending you a copy of the third report and make inquiry about a matter which has more urgency now than it had in January.

As you can see, research progress has proceded very much as planned and we have had word from the SCS laboratory that they have completed the analyses on the soils we sent them. We were quite successful in determing external P requirements for one of the Costa Rican bean varieties on the CATIE station although the soil would only be considered of moderate P-retention capacity.

Our problem , as mentioned in the reports, relates to the increase in cost of the graduate program at CATIE since the project was started. The cost of maintaining a student here has increased from $12,000 to $22,000. Unfortunately, we only budgeted $24,000 for the two M.S.theses because that was the official cost of maintaining two students here at the time the proposal was submitted. Fortunately, the first student to complete his M.S. under the project had already completed a year of course work so he was able to finish his M.S. thesis at a cost of only some $12,000. So we had $12,000 for the second student but now we need $10,000 more for him to finish. Another problem involved the late arrival of the project vehicle which necessitated delaying the field work fom Oct, 1986-April, 1987 to Oct, 1987- April, 1988 as beans are only planted in this period in the project area. Unfortunately, the salary for the field assistant was only budgeted until the end of 1987 since the field work should have

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been finished by then. Now, it won't be finished until April, 1988; so we would need another $3000 to pay the field assistant for another five months. The additional $13,000 we are thus requesting would not put the total project cost over the $150,000 limit since the present cost is now only $134,000.

Thank you very much for your attention to this matter. As you can see from the progress reports, the results obtained to date would seem to justify the additional expenditure. We also prepared a new preproposal on the use of organic Phosphorus sources in soils of volcanic origin for which AID-SCI has invited us to write the full proposal, which should be submitted shortly. We should be able to use some of the soils characterized in the present project in the new project.

Thank you again for your attention and cooperation.

Very truly yours.

Don

Donald L. Kass

Principal Investigator
Professor of Soil Physics
and Management
Higher Education Project

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Interim Progress Report no. 1
Aug 1, 1985 - May 1, 1986

Project AID-SCI 936-5442

Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

A. Research Progress'

A total of 15 sites have been sampled to date. Further progress in this area should be obtained within the month of May as CATIE put a vehicle at the disposal of the University of Costa Rica for this purpose on April 15. Following suggestions of Dr. Hari Eswaran of SMSS, efforts are being made to utilize sites for which SMSS has made mineralogical characterizations in connection with other AID projects. There are a total of 22 such sites in Costa Rica and Pananma but not all of them present the P retention characteristics or the climatic conditions for bean production required by the project.

A total of 25 P retention isotherms have been run on soils from 10 of the sites in the CATIE laboratory. Some of these isotherms are included in figure 1. The results in general compare well with the differences predicted by Fox and Searle (1978).

In the figure, it can be seen that the soil from La Lola, despite its formation on volcanic material, has low P retention characteristics. The mineralogical charcterization of this soil, however, shows a high proportion of 2:1 ype clays, which explain its P retention characteristics as evidenced in the isotherm. The curves obtained for the CR-14 and Trinchera soils are characteristic of soils with high levels of exchangeable aluminum. DTA analysis of the CR-14 soil, carried out at the SCS laboratory in Lincoln, Nebraska, showed the clay fraction to be 36% Kaolinite and 30% Gibbsite. Similarly, the curves for the Cerro de la Muerte soils are representative of Dystrandepts but the soils also have spodic characteristics. The ganaderia soil is supposed to show characteristics of a soil

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with P retention dominated by amorphous materials. Mineralogical analysis showed the clay fraction to be predominately Halloysitic with low levels of exchangeable Al (less than 1 meq/100 g soil) However, the isotherm resembles more that of a soil where crysalline aluminum and iron oxides dominate the clay fraction. The organic carbon of the surface layer is high (3.84%) but the Halloysite may well demonstrate P retention characteristics intermediate between allophnae and Kaolinite. More determinations on soils with similar mineralogical characteristics will be necessary to determine whether this pattern is to be expected in soils where halloysite predominates.

Soils selected for the greenhouse experiments are (1) fine Kaolinitic, isohyperthermic, typic Hapludult (buenos Aires, Costa Rica); (2) coarse, loamy, mixed isohyperthermic Andeptic Dystropept (Cariari, Costa Rica) and (3) a fine isohyperthermic, halloysitic Typic Humitropept (Turrialba, Costa Rica). These represent soils which retain phosphorus because of exchangeable aluminum (1)., amorphous materials (2) and both mechanisms (3). Mineralogical characterizations of these soils was done by SMSS in connection with previous ROCAP projects.

The greenhouse experiments should begin in May, 1986. These will serve as thesis research for Ing. Wilbert Campos Alvorado, a Costa Rican student in the CATIE-UCR MSc. program who began receiving a scholarship from the project on March 31, 1986.

Laboratory equipment was ordered in November, 1985; but has not yet arrived. Existing equipment is being utilized but better results could probably be obtained with new equipment.

The UCR soil taxonomist has described ten profiles with characteristics suitable for the project. Laboratory analyses on these soils are in progress. A further five soils have been selected from those described by SMSS as suitable for project purposes. The remaining fifteen soils should be selected and described by the end of July.

Changes in research plans:

Although there have been some delays due to late arrival of funds and the necessity of making a cooperative agreement with the University of Costa Rica for execution of the project, project activities are not proceeding much behind schedule. Collection of samples and profile descriptions should be finished at the end of July, about 6 months late but not too late to affect planting of field experiments which should occur in September. Soils for the greenhouse experiments are already selected and experiments should begin in May. There have been some delays in the ordering of equipment and reagents but the orders are presently being processed by CATIE's purchasing department. Germplasm has been obtained from CIAT and MAG (Costa Rica). All personnel for the project have been hired byCATIE and UCR.

A possible source of difficulty is the increase in the cost of supporting a graduate student at CATIE. The project originally envisaged suppoerting two M.S. students, which at the time the project was written , would cost $6000 per student per year. Unfortunately, CATIE presently estimates the cost of a graduate student at $10,500 per year. Fortunately, the project selected a graduate student who had already completed one year of study. His cost for terminating his M.Sc. thesis has been calculated at $9000. This would leave us with $15,000 to support the other student who should be selected from the group due to enter in September, 1986. We would therefore need an additional $6000 for support of graduate students, but only in 1988. It was thought that some money could be transferred if a more inexpensive vehicle [illegible] purchased for the project but it seems impossible to find a vehicle of the required specifications for less than [illegible] $12,000 budgeted. Suggestions on ways to resolve this problem would be appreciated. It is not that urgent because the shortage corresponds to the support of the student only in 1988 but it should be considered in due course.

We have not yet sent any samples to the U.S. for mineralogical analyses. Inquiries were made to the SCS laboratory in Lincoln Nebraska and to SMSS concerning cost of such determinations. Dr. Hari Eswaran of SMSS suggested that we utilize some of the 55 Central American sites for which SMSS has already done mineralogical analyses. Unfortunately, twenty of those sites are in Costa Rica but only two in Panama. Many of the sites in Costa Rica , however, are, for climatic reasons, not suitable for bean culture. It should, however, be possible to utilize 10 or 15 of the sites already characterized. This would leave 20 mineralogical characterizations to be made in U.S. laboratories for which the funds budgeted for the soil classification consultant should be adequate.

Dr. Eswaran also suggested that project activities be integrated with IBSNAT. Durimg March of 1986, CATIE was visited by DR. F. Beinroth of IBSNAT. In discussions about what IBSNAT was looking for, it appeared that the type of experiments envisaged in the project indeed could be of much use to IBSNAT if more data were taken on factors such as biomass production over time, climatic characterization of the conditions during the experiments, and soil moisture over the course of the experiment. Unfortunaltely, taking such data would increase the costs of these experiments far beyond the budget of this project. It would seem unlikely that IBSNAT would be able to provide these funds by September when the field experiments should begin. Unfortunately, they would thus be losing a great opportunity to obtain data for their data sets.

During a visit to IFDC, the CATIE head of soil laboratory, Roberto Diaz Romeu spoke with specialists of that institution. In reviewing the project, they mentioned the possibility that aluminum fixed in the organic matter might also retain phosphorus. There is evidence that mechanism indeed functions in Costa Rican Soils . Separation of this aluminum is not a difficult procedure but requires $LaCl_3$, which is relatively expensive. This reagent was not included in those originally requested for the project. Purchase of this reagent for these analyses might require another $2000.

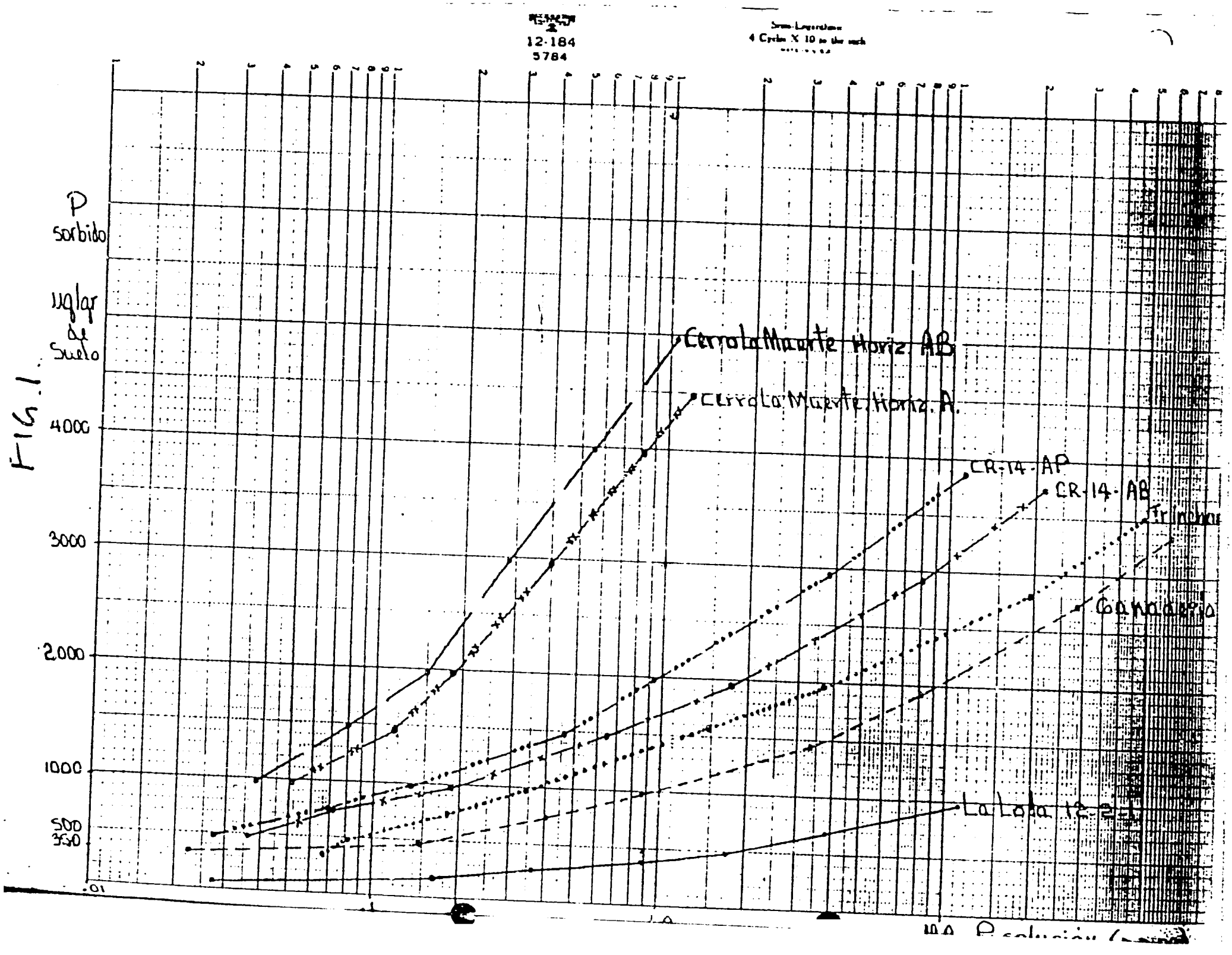
FIG. 1
P sorbido
Jugar de Suelo
4000
3000
2000
1000
500
350
.01
Cerro La Muerte Horiz. AB
Cerro La Muerte Horiz. A
CR-14-AP
CR-14-AB
Trinchera
Ganadería
La Loma 12-2

Key dates or benchmarks

Aug. 1, 1985	Project agreement signed
Sept.6, 1985	Work plan submitted for first year of project
Sept. 30, 1985	Funds deposited
Oct. 9, 1985	Soil mineralogy consultant begins work on P retention isotherms
Nov. 1. 1985	Equipment and reagents ordered
Dec. 17, 1985	Agreement between CATIE and UCR signed
Jan. 31, 1986	UCR receives funds from CATIE. Field assistant hired, University soil classification specialist began sampling.
March 31, 1986	Laboratory assistant transferred from IFAD project to P retention project. Wilbert Campos Alvorado, a MSc. student in the CATIE-UCR project received scholarship from project
April 15, 1986	Thesis proposal of Ing. Campos submitted. He began collecting soils for greenhouse experiments.
April 16, 1986	CATIE supplied vehicle to UCR for collection of soil samples.
May 1, 1986	Study of P absorption capacity of bean seeds begun
May 15, 1986	UCR should complete trips for description and classification of soils. Greenhouse experiments should begin
July 1, 1986	Soil samples should be sent to U.S. for mineralogical characterization.
Sept.1, 1986	Second MSc. student should be chosen
Sept. 15, 1986	Field experimentation should begin.

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Interim Progress Report # 2

May 1,1986- Nov. 1, 1986

Project AID-SCI 936-5442

Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

I. Research progress

Considerable progress was made in all areas during this period.All thirty soils specified in the project have been identified and described. P retention Isotherms have been run on three horizons on all of the soils. Available mineralogical information on some sixty Central American soils has been compiled and indexed. On this basis, fifteen of the thirty soils have been selected for mineralogical analyses since such information is lacking for the areas that these soils represent. One of the students receiving a scholarship under the project has completed his research activities. Finally, a second scholarship student has been selected and has begun his M.S. program at CATIE.

A. Soils Descriptions

Thirty sites in Costa Rica and Panama which were considered to fulfill the characteristics suggested by the project have been identified, described, and relevant analyses run. Twenty of the soils would appear to fix phosphorus primarily due to the presence of amorphous materials resulting from the weathering of volcanic materials. Only one of the soils would appear to fix phosphorus

primarily due to the presence of exchangeable aluminum whose origin may or may not be from volcanic materials.It may therefore be necessary to locate more sites where P retention is primarily due to precipitation reactions. Such sites are probably not as common in Panama and Costa Rica as was originally supposed. Such soils were expected to occur in several sites in the Atlantic zone of Costa Rica and the General River valley as well as in Panama. However, low levels of exchangeable aluminum were found in sites sampled in Upala(Profiles 10 and 11) and in San Carlos (Profiles 28 and 29). sites in the General valley (Profile 19) and Rio Frio (Profiles 35 and 36) proved to have higher levels of amorphous aluminum (pH values in NaF above 10.0) than expected.

Finally, there are nine soils in which both the presence of amorphous materials and exchangeable aluminum might be contributing to P retention properties. There are an additional five soils, in which the analyses do not indicate the likelihood of a significant degree of P retention.

Of these soils, fifteen have been selected for which no mineralogical information exists. Arrangements have been made by one of the principal investigators to have these characterizations run at the USDA-SCS Soils Characterization Laboratory in Lincoln, Nebraska. This includes the separation of clays, a time-consuming procedure due to the necessity of separating organic matter, which is quite high in the soils of volcanic origin. The agronomist hired under the project is presently engaged in this activity, which should be finished within two months. It is hoped to send the first of the samples to

Lincoln at the end of November.

B. P adsorption isotherms.

P adsorption isotherms have been run on three horizons of each of the thirty soils identified and described above. Although all of the laboratory equipment ordered under the project has not yet arrived, one of the principal investigators was able to secure an advance of $1300 from CATIE and was able to purchase some of the most essential items while on vacation in U.S. in July. As a result, it was possible to terminate the isotherms in somewhat less time than anticipated even though the assistant agronomist doing this work attended the course in management of tropical soils given by AID in Yurimaguas, Peru, in August. Some of the isotherms are presented with the soils descriptions(fig.1) .The Fraijanes and Barbacoas soils show P sorption isotherms rather characteristic of Hydrandepts and Dystrandepts respectively. The Soledad and Sanitorio soils show rather less P retention than their classification as Hydrandept and Dystrandept respectively would indicate. The Na F values are below 10.0 for all horizons of both soils. While heavy application of P fertilizer might affect the P sorption isotherm of the Sanatorio soil, such applications are supposed to bring about a horizontal shift of the isotherm (Fox and Searle,1978). Such a shift would still give rather low retention values for the Sanatorio soil. Considerable P adsorption was found for certain soils, especially those in Puriscal, where it was not previously considered to be a major limitation to crop production. Also, very high fixation levels were found for the Caizan region of Panama, the most important bean producing area of that country, where the M.S. student

recently admitted to the program with a scholarship from the project, will most probably do his thesis research.

C. Screening for low phosphorus tolerance, seed and foliar uptake of phosphorus(M.S Thesis research of Ing. Wilbert Campos)

Ing. Campos has completed several studies related to developing practical alternatives for soils with high P retention characteristics. As was pointed out in the previous report, three soils characterized by the USDA-SCS laboratory in work with previous ROCAP projects were selected for the greenhouse work. Ing. Campos proceeded to run P adsorption isotherms on these soils and determine deficiencies of other elements which would have to be supplied for the greenhouse work. He then tested several concentrations, formulations, and times of imbibition of phosphorus containing solutions for the bean variety ICA-Pijao. Results of this work are presented in Table 1. It can be seen that

soaking for 3 hours in a solution of KH_2PO_4 containing 8000 ppm of P led to increase of 0.35 g/g P in the bean seed without

significantly reducing bean germination or emergence. While this is practically double the original P content of the bean seed, the actual amount of P supplied would probably not be significant on a per hectare basis as 100 kg of bean seed would only contain 530 g of P which could be increased to 880g by the soaking. However, it may be possible that having this amount of extra phosphorus already in the bean seed will greatly stimulate growth. It should be remembered that a 1000 kg ha^{-1} bean crop may contain only 3 kg of phosphorus. Field testing of this practice will be started

in November.

Following this work, Ing. Campos proceeded to set up the greenhouse experiment, using three soils for which mineralogical analyses, run by the SCS laboratory, indicated that different mechanisms of P retention should be operating. The experiment was a complete factorial with three soils X 4 bean varieties X 2 lime levels X 4 methods of P application (none, seed imbibition,foliar,seed imbibition and foliar) with four repetitions. Very good response to liming was observed in the Montana (Turrialba) soil which had the highest level of exchangeable aluminum although aluminum saturation was higher in the Buenos Aires soil, which is probably an Ultic Haplorthox.P adsorption isotherms for the three soils with and without liming are given in Figures 2 and 3. It can be seen that differences in the isotherms are slight, despite a considerable difference in classification and presumably in the mechanisms of P retention. Liming the soils (Fig.3) produced very small changes in the P sorption isotherms, although the changes are in the direction indicated in the literature (Haynes, 1984). Phosphorus retention by the Cariari soil where amorphous material predominates was increased by liming while the Montana and Buenos Aires soils with more crystalline material showed a slight reduction in in P retention.

Although the level of Olsen available P was lower in the Cariari soil (an Andeptic Dystropept) than in the Turrialba soil (a Typic Humitropept), there were no signs of P deficiency in any of the bean plants in the Cariari soil which supposedly has the highest P

retention characteristics of the three soils. No response to any of the methods of P application was noted but there seemed to be some varietal difference in the degrees of P deficiency observed in the Turrialba and Buenos Aires soils. The pots were harvested in early November and the plant and soils being analyzed for Phosphorus and Calcium content. The results should be available for the next interim report as Ing. Campos should finish his thesis by March, 1987. A field experiment with similar treatments will be planted on the Montana soil in Turrialba in late November or early December. Field experiments on the other soils will not be possible because the vehicle ordered by the project has not yet arrived.

II. Changes in research plans

As noted above, the major change in research plans is the postponement of the field experiments stage for one year, mostly due to the failure of the project vehicle to arrive. CATIE no longer has available extra vehicles to loan to the project as was done in May-June, 1986, for the soil sampling phase. Since the project is not supposed to terminate until November, 1988, there would still be time to analyze the results of field experiments carried out in the period of September, 1987- March, 1988 before the termination of the project. By September, 1987, the results of the mineralogical characterizations should be available as well as a complete analysis of the greenhouse experiments. For these reasons, the postponement of the field experimentation until September, 1987, will have certain advantages.

Results obtained so far in the research would seem to indicate that little relationship can be established between the U.S. soil taxonomy and P retention capacities of various central American soils. reviewers of the original project proposal maintained that such a relationship could be established. However, the U.S. taxonomy, as least as it has been applied by USDA personnel in Central America does not always gives a very accurate picture of either soil mineralogy or soil P retention. Thus, the classification of the soil from Quezada, Jutiapa, Guatemala, as a fine, mixed, isohyperthermic Vertic Haplustoll by SCS personnel(Table 2) reflects neither its predominantly halloysitic mineralogy nor its fairly high P retention capacity. The soils from Veraguas, Panama , and Matagalpa , Nicaragua only differ in the taxonomy with regard to textural class (Table 2). Both soils apparently contain considerable amorphous material as indicated in the X-ray analysis, but not surprisingly by their pH in NaF. In other cases, the mineralogical characterization fails to identify sources of P retention which must be present. X- ray analysis of the Juray series on the CATIE station revealed only rather low levels of Halloysite and Gibbsite but nor amorphous material. Yet, P retention by the New Zealand test was 74% and pH in NaF met the requirement for andisols. Apparently, the taxonomy is not yet sufficiently evolved for the purposes of this project. Amorphous iron and aluminum coatings on the clays, not revealed by the X-ray analysis, may be making a major contribution to P retention.

Despite these findings. there is no reason to abandon the plan of activities originally scheduled for the project. It was not the original intention of the principal investigators to base a system for indexing soils with respect to their P retention capacities on the U.S. soil taxonomy-- in fact, the original project proposal said this would be unlikely. It is hoped, in the course of the project, to be able to test other means of characterizing soils such as Al extracted by $LaCl_3$,ammonium oxalate, or KOH which could be correlated with P retention properties(Kimble, 1984; Parfitt,1980).

During June, 1986, the project was visited by an Ms. Ferguson, of Colorado State University, who informed the principal investigator that she was sent by AID to review the project. As her report shows, she had little knowledge of soil science and could not adequately evaluate project activities. A copy of her report is included.

Both of the principal investigators attended the ISSS meetings in Hamburg, Germany, in August, 1986, not paid by project funds. They were able to consult with several authorities in the field of P retention and volcanic soils. No one was able to offer much information on the P retention properties of Halloysite, however.

Benchmark Dates

November, 1986	Soils sent to Lincoln, Nebraska, for for mineralogical characterization.
	Isotherms completed
	Field experiment in Turrialba, planted.
December, 1986	Presentation of first project results at ASA meetings in New Orleans, La.
January, 1987	Separation of clays completed
	Second group of soils sent to Lincoln.
March, 1987	Wilbert Campos finishes M.S. thesis
	Further chemical analyses completed (Al in oxalate; Al in KOH)
	Harvest of field experiment in Turrialba
April, 1987	Project vehicle arrives Further site identification
May, 1987	First results of mineralogical analyses from SCS
June, 1987	Ing. Samudio submits thesis proposal
Sept.,1987	Field experimentation in Panama and Costa Rica begin

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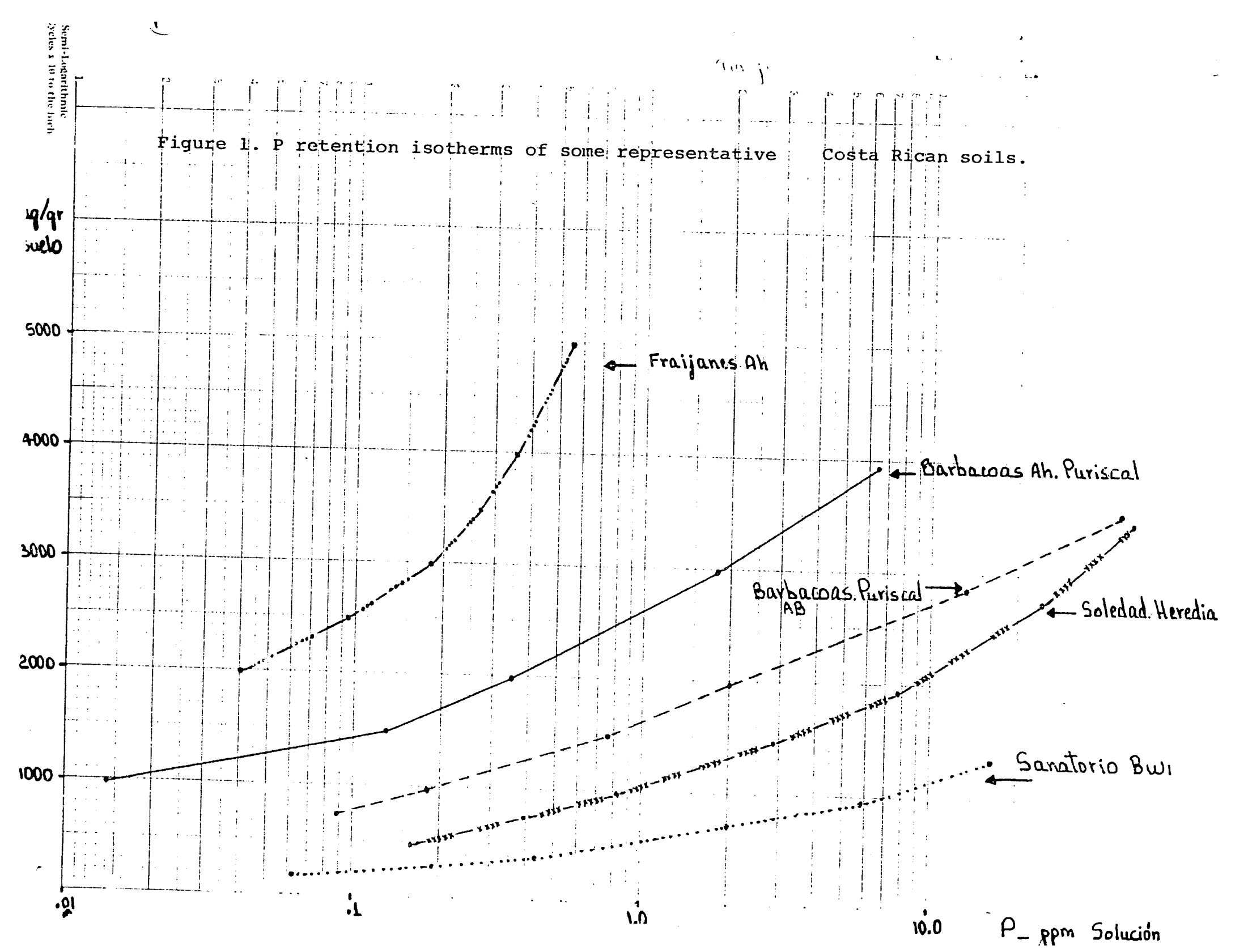

Figure 1. P retention isotherms of some representative Costa Rican soils.

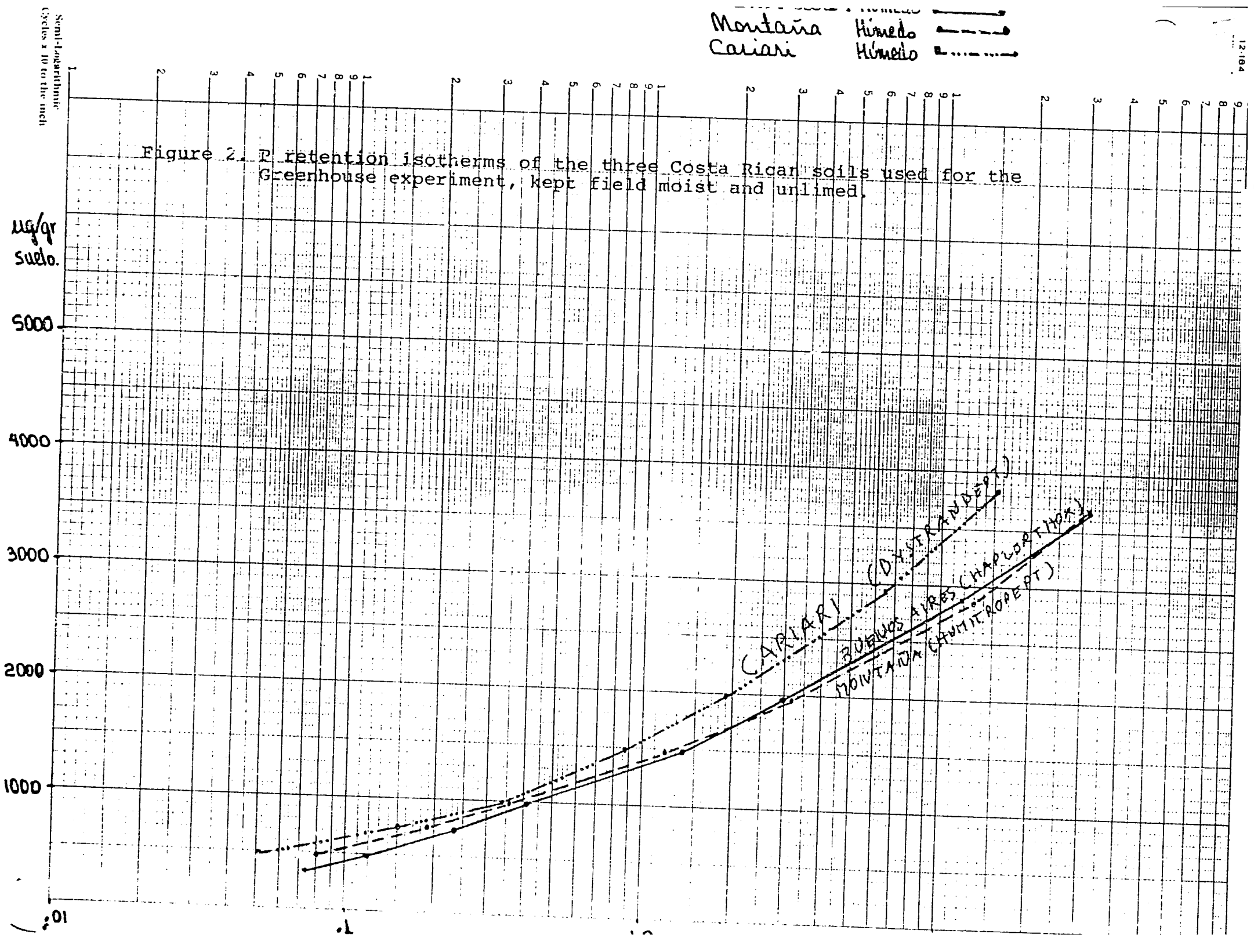

Figure 2. P retention isotherms of the three Costa Rican soils used for the Greenhouse experiment, kept field moist and unlimed.

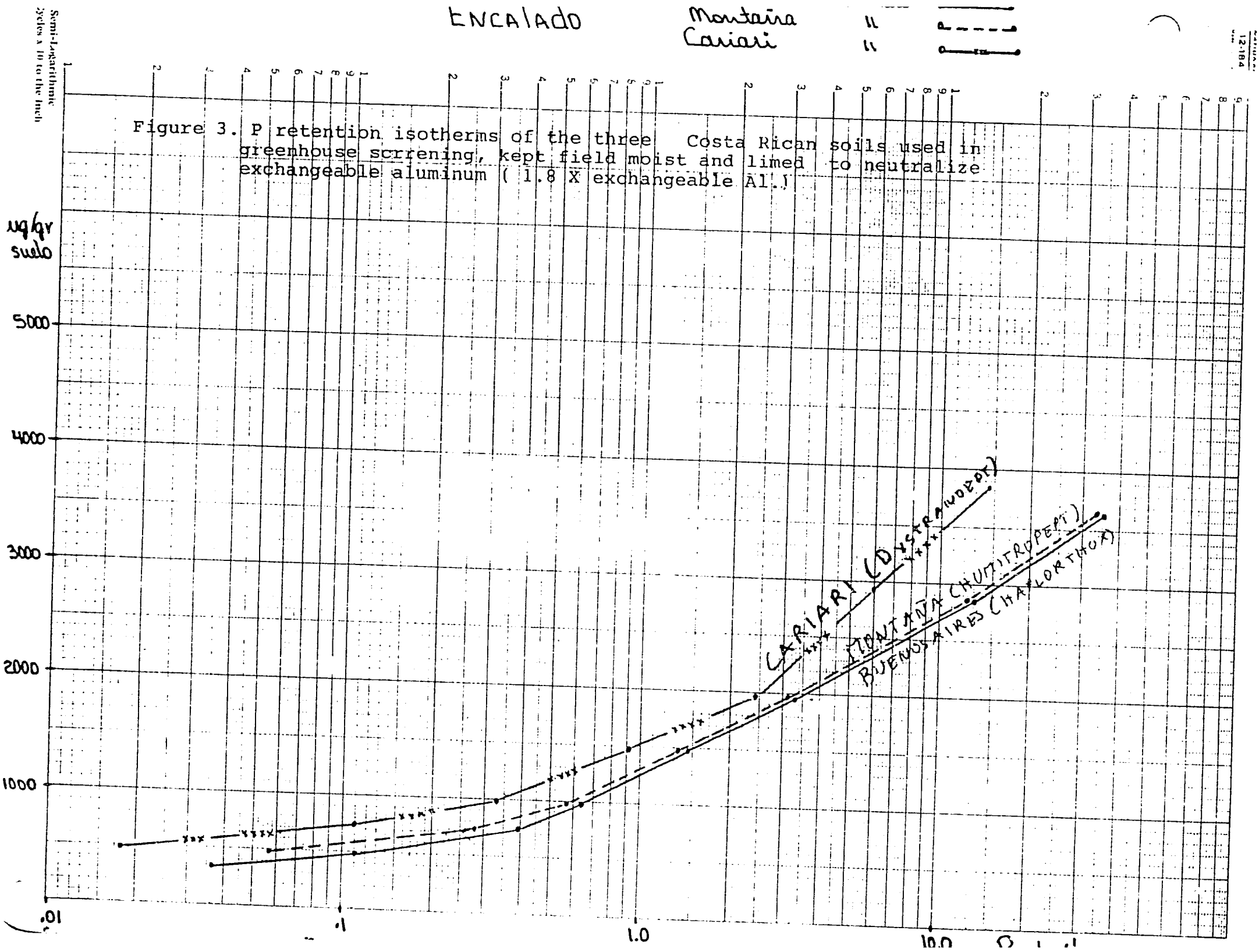

Figure 3. P retention isotherms of the three Costa Rican soils used in greenhouse screening, kept field moist and limed to neutralize exchangeable aluminum (1.8 X exchangeable Al.)

TABLE 1. EMERGENCE, GERMINATION, AND P CONTENT OF SEEDS OF *PHASEOLUS VULGARIS*, L., VAR. ICA-PIJAO, FOLLOWING DIFFERENT PRESOAKING TREATMENTS FOR THREE HOURS

PRESOAKING TREATMENT	EMERGENCE (SEEDS/100)	GERMINATION (SEEDS/100)	P CONTENT (MG/G)
UNTREATED	80 A	93 A	5.3 E
DISTILLED WATER	73 AB	90 AB	4.8 E
K_2HPO_4 -2000PPM P	57 ABC	67 BC	5.4 E
-4000PPM P	53 BC	57 C	6.9 C
-6000PPM P	57 ABC	63 C	7.9 B
-8000PPM P	60 ABC	70 ABC	8.8 A
-10000PPM P	23 DE	27 DE	9.2 A
$NH_4(H_2PO_4)$			
-2000PPM P	40 CD	47 CD	6.1 D
-4000PPM P	17 DE	27 DE	7.0 C
-6000PPM P	7 E	13 E	7.9 B

VALUES FOLLOWED BY THE SAME LETTER DO NOT DIFFER BY DUNCAN'S MULTIPLE RANGE TEST AT P 0.05

TABLE 2. LOCATION, MINERALOGY, CLASSIFICATION, AND P RETENTION OF CENTRAL AMERICAN SOILS CLASSIFIED FOR THE ROCAP- SMALL FARMER CROPPING AND FARMING SYSTEMS PROJECTS

LOCATION	CLASSIFICATION	HORIZON SAMPLED	MINERALOGY	NEW ZEALAND P-RETENTION	PH-NAF	AL. SAT
JURAY SERIES; TURRIALBA, CR	FINE, MIXED, ISOHYPERTHERMIC TYPIC DYSTROPEPT	BA: 23-48CM	KH-2; GI-1	74	9.9	0
INSTITUTO SERIES TURRIALBA, CR	FINE, HALLOYSITIC, ISOHYPER-THERMIC TYPIC HUMITROPEPT	BW_2:33-58 CM	KH-3; GI-3;		9.9	10
CARIARI, COSTA RICA	COARSE-LOANY, MIXED, ISOHY-PERTHERMIC AQUIC DYSTRANDEPT	BW_1:22-45 CM	KH-1; GI-1	98	10.5	N.D.
BUENOS AIRES, COSTA RICA	FINE, KAOLINITIC, ISOHYPER-THERMIC TROPEPTIC HAPLORTHOX	B: 61-92 CM	KK-3; GI-2; GE-1		9.2	100
COMAYAGUA, HONDURAS	VERY-FINE, MONTMORILLONITIC, ISOHYPERTHERMIC CUMULIC HAPLUSTOLL	A_1: 15-45 CM	MT-4	20	8.3	
LA ESPERANZA, HONDURAS	CLAYEY, HALLOYSITIC, ISOTHER-MIC HUMIC USTOX	BT_1:17-40 CM	KH-3; GI-1	52	9.5	26
QUEZADA, JUTIAPA GUATEMALA	FINE, MIXED, ISOHYPERTHERMIC VERTIC HAPLUSTOLL	A_F: 0-30 CM	KH-4; MT-1	66		
CAUQUE SERIES, SANTIAGO SAC. GUATEMALA	MEDIAL, ISOTHERMIC TYPIC EUTRANDEPT	BW_1: 60-100CM	KH-2; FD-1	70	9.3	
VERAGUAS, PANAMA	VERY FINE, MIXED, ISOHYPER-TYPIC TROPUDALF	BT_2: 42-78	KH-3; NX-6		9.4	24
MATAGALPA, NICARAGUA	FINE, MIXED, ISOHYPERTHERMIC TYPIC TROPUDALF	A/B: 15-49	KH-2; NX-6		9.2	18
NUEVA CONCEPCION LA REINA EL SALVADOR	FINE-LOAMY, MIXED, ISOHYPER-THERMIC UDIC HAPLUSTALF	B_T : 20-50	KH-3; MI-2; CR-1	22		0

KH- HALLOYSITE; MT- MONTMORILLONITE; KK-KAOLINITE; GI_GIBBSITE
GE- GOETHITE; CR- CRISTOBALITE; MI-MICA

I. _ INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 13.

Nombre del suelo: Bijagua.

* Clasificación: Typic Dystrandept.

Fecha de observación: 29-4-1986.

Ubicación: Bijagua de Upala, frente al salón el cinco.

Altitud: 450 msnm.

Forma del terreno: Ondulado.

Pendiente: 6-12 %

Uso de la Tierra: Maíz, pastos, charral.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Cenizas volcánicas.

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Ligera.

III. DESCRIPCION DEL PERFIL:

Ah1 0-20 cm Pardo oscuro (10 YR 4/4) en seco; franco arenoso; estructura granular, fina y moderada; friable, no adhesivo ni plástico, blando; abundantes poros y raices de todos los tamaños; límite claro y plano; pH 6,0.

Ah2 20-36 Pardo (10 YR 5/4) en seco; franco arcillo arenoso; estructura en forma de bloques subangulares y granular ; friable, no

		adhesivo, ni plastico, blando; abundantes poros; abundantes raíces muy finas y finas; límite claro y plano; pH 6,2.
AB	36-50	Rojo amarillento (7,5 YR 6/6) en seco; arcilloso; piedra de menos de 5 cm de diametro en menos del 5% del volumen; estructura en bloques subangulares que rompe en granulos; friable , ligeramente adhesivo y plastico; abundantes poros; frecuentes raíces muy finas, finas y medianas; límite claro y plano; pH 6,7.
Bw1	50-100	Rojo amarillento (7,5 YR 6/6) en seco; franco arcilloso; presencia de piedras y grava en menos del 10 % del volumen; estructura en forma de bloques subangulares, finos y moderados; ligeramente adhesivo y plastico; frecuentes poros , pocas raíces medianas; límite claro y plano; pH 6,4.

BUDGET FOR SECOND YEAR OF PROJECT AID-SCI 936-5442

Supplement for university soil chemist	$ 2000
Supplement for university soil classifier	2000
B.S. Agronomist	6000
Laboratory assistant	4000
Labor for field experimenhs	5000
Books/photocopies	1000
Fertilizers	500
Trips for field experiments	1500
Scholarships	12000
Fuel	2000
Overhead	10000
Analysis in CATIE laboratory	2000
	51000
Unspent from first year	
Consultant in soil classification	6000
Shipment of soil samples	500
Analysis in CATIE laboratory	1500
	8000
Total available for second year	$59000

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 6

Nombre del suelo: Sanatorio Durán.

Clasificación: Typic Hydrandept.

Fecha de observación: 11-3-1986

Ubicación: Entrada de la Estación Experimental Carlos Durán.

Altitud: 2250 msnm.

Forma del terreno: Escarpado.

Pendiente: 20-40 %.

Uso de la Tierra: Pastos y papa.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Formas de origen volcánico (andesitas).

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Ligera.

III. DESCRIPCION DEL PERFIL:

O -10-0 cm Cama de raices en descomposición.

Ah1 0-20 Pardo grisaceo oscuro (10 YR 4/2) en húmedo; textrura franco-arenosa; estructura granular, fina y muy fina, débil; friable, no adhesivi ni plástico; abundantes poros; abundantes raices; límite gradual y plano; pH 5,9.

Ah2 20-45 Pardo grisaceo (2.5 Y 5/2) en húmedo; franco

arenoso; bloques subangulares y granular, finos y medianos, moderados; friable, no adhesivo ni plástico; abundantes poros y raíces; límite gradual y plano; pH 5.8.

Bw 45-100 Pardo (10 YR 5/3) en húmedo; franco arenoso; estructura en blogues subangulares y granular, finos y medianos, moderados; friable, no adhesivo ni plástico; abundantes poros y raíces finas y muy finas; límite gradual y plano; pH 5,9.

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PERFIL 6. SANATORIO DURAN (CARTAGO)

HORIZONTE	Ah1	Ah2	Bw
Profundidad cm	0-20	20-45	45-100
pH H2O	5,9	5,8	5,9
pH KCl	4,7	4,5	4,9
pH NaF	9,6	9,5	9,6
Cmol (+)/kg*			
Ca	6,0	6,4	8,4
Mg	2,0	2,3	2,1
K	1,07	0,82	0,22
CIC	21,4	23,6	24,5
SAT. BASES(%)*	42,2	40,4	43,4
Cmol (+)/kg**			
Ca	5,4	5,8	7,7
Mg	1,3	1,3	1,2
K	0,87	0,67	0,18
Acidez	0,5	0,6	0,2
CICE	8,1	8,4	9,3
SAT. BASES (%)**	93,8	92,9	97,9
SAT.ACIDEZ (%)	6,2	7,1	2,1
mg/kg			
P	50	55	21
Cu	12	14	9
Zn	9	13	8
Mn	9	5	3
Fe	328	326	227
MAT. ORG. (%)	2,75	4,02	4,62
% ARENA	62	56	54
% LIMO	24	26	27
% ARCILLA	14	18	19
NOMBRE TEXTURAL	Fa	Fa	Fa

Fa= Franco-arenoso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores: y KCl 1N para Ca, Mg y acidez.

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PERFIL 29. POCO SOL (SAN CARLOS)

HORIZONTE	Ah	AB	Bt
Profundidad cm	0-25	25-44	44-120
pH H2O	6,1	6,2	6,3
pH KCl	4,9	5,2	5,6
pH NaF	9,0	9,2	8,9
Cmol (+)/kg*			
Ca	6,0	4,2	3,5
Mg	3,2	2,9	3,6
K	0,32	0,20	0,06
CIC	20,6	20,9	15,1
SAT. BASES(%)*	46,4	34,6	47,5
Cmol (+)/kg**			
Ca	7,6	6,1	4,6
Mg	3,4	3,1	3,7
K	0,46	0,27	0,12
Acidez	0,4	0,3	0,3
CICE	11,9	9,8	8,7
SAT. BASES (%)**	96,6	96,9	96,6
SAT.ACIDEZ (%)	3,4	3,1	3,4
mg/kg			
P	3	2	1
Cu	16	21	17
Zn	6	7	4
Mn	17	13	2
Fe	111	64	31
MAT. ORG. (%)	5,65	2,70	1,45
% ARENA	36	12	6
% LIMO	16	3	7
% ARCILLA	48	85	87
NOMBRE TEXTURAL	A	A	A

A= Arcilloso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 29.

Nombre del suelo: Poco Sol.

Clasificación: Typic Tropohumult.

Fecha de observación: 2-6-1986

Ubicación: Asentamiento del IDA en Poco Sol, Finca de Wilson Valerio.

Altitud: 80 msnm.

Forma del terreno: Muy ondulado.

Pendiente: 20 %

Uso de la Tierra: Pastos.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Lahares finos.

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Moderada.

III. DESCRIPCION DEL PERFIL:

Ah 0-25 cm Pardo rojizo oscuro (5 YR 3/3) en húmedo; arcilloso; estructura granular, fina y mediana, fuerte; ligeramente firme, adhesivo y plástico; abundantes poros; abundantes raices muy finas, finas y medianas; límite claro y plano; pH 6,1.

AB 25-44 Pardo rojizo oscuro (5 YR 3/4) en húmedo;

arcilloso; estructura en bloques subangulares que rompe a granular, fina y mediana, fuerte; ligeramente firme, adhesivo y plástico; abundantes poros; frecuentes raíces finas y muy finas; límite claro y plano; pH 6,2.

Bt 44-120 Rojo amarillento (5 YR 4/6) en húmedo; arcilloso; bloques subangulares, medianos y fuertes; ligeramente firme, adhesivo y plástico; abundantes revestimientos de arcilla; abundantes poros finos, muy finos y medianos; frecuentes raíces muy finas; límite claro y plano; pH 6,3.

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 28.

Nombre del suelo: La Trinchera.

Clasificación: Typic Humitropept.

Fecha de observación: 03-06-1986.

Ubicación: La Trinchera de Pital de San Carlos, Finca del señor Oscar Lizano.

Altitud: 125 msnm.

Forma del terreno: Plano.

Pendiente: < 3%

Uso de la Tierra: Piña.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Lahares sin diferenciar.

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Ligera.

III. DESCRIPCION DEL PERFIL:

Ap 0-20 cm Pardo oscuro (10 YR 3/3) en húmedo; franco arcillo arenoso; estructura granular fina muy fina, débil; friable, no adhesivo ni plástico; abundantes poros; abundantes raíces; limite gradual y plano; pH 5,8.

AB 20-32 Pardo oscuro (7,5 YR 3/4) en húmedo; arcilloso; estructura en bloques subangulares

		y granular, fina y muy fina, moderada; friable, ligeramente adhesivo y ligeramente plástico; límite gradual y plano; pH 5,7.
Bw	32-120	Pardo oscuro (7,5 YR 3/4) en húmedo; arcilloso; estructura en bloques subangulares, finos y medianos, moderados; friable, ligeramente adhesivo y ligeramente plástico; límite gradual y plano; pH 6,0.

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PERFIL 28. TRINCHERA (SAN CARLOS)

HORIZONTE	Ap	A3	Bw
Profundidad cm	0-20	20-32	32-120
pH H20	5,8	5,6	6,0
pH KCl	4,9	4,8	5,2
pH NaF	9,1	9,3	9,5
Cmol (+)/kg*			
Ca	11,8	8,2	9,8
Mg	6,2	5,1	3,3
K	2,34	0,98	0,30
CIC	34,7	32,3	27,0
SAT. BASES(%)*	58,7	44,1	49,9
Cmol (+)/kg**			
Ca	12,3	10,7	12,6
Mg	5,1	4,7	3,1
K	0,99	0,41	0,39
Acidez	0,6	0,6	0,4
CICE	19,0	16,3	16,4
SAT. BASES (%)**	96,8	96,3	97,6
SAT.ACIDEZ (%)	3,2	3,7	2,4
mg/kg			
P	12	5	6
Cu	30	26	28
Zn	12	8	12
Mn	59	45	17
Fe	77	63	86
MAT. ORG. (%)	6,18	3,68	1,84
% ARENA	51	39	29
% LIMO	17	19	13
% ARCILLA	32	42	58
NOMBRE TEXTURAL	FAa	A	A

A= Arcilloso FAa= Franco-arcillo-arenoso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

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PERFIL 36. RIO FRIO II

HORIZONTE	Ah	B1	Bt
Profundidad (cm)	0-20	20-35	35-72
pH H20	5,2	5,4	5,3
pH KCl	4,3	4,4	4,5
pH NaF	10,0	10,4	10,5
Cmol (+)/kg*			
Ca	2,5	1,9	1,0
Mg	3,1	2,0	1,0
K	0,26	0,12	0,15
CIC	28,3	31,2	29,5
SAT. BASES(%)*	20,7	12,9	7,2
Cmol (+)/kg**			
Ca	1,7	1,1	0,7
Mg	1,7	1,3	0,8
K	0,18	0,09	0,19
Acidez	2,4	1,9	1,5
CICE	6,0	4,4	3,1
SAT. BASES (%)**	59,7	57,0	51,9
SAT. ACIDEZ (%)	40,3	43,0	48,1
mg/kg			
P	4	3	3
Cu	37	32	23
Zn	6	8	5
Mn	28	13	8
Fe	244	200	100
MAT. ORG. (%)	9,33	4,93	3,55
% ARENA	58	62	58
% LIMO	21	13	13
% ARCILLA	21	25	29
NOMBRE TEXTURAL	FAa	FAa	FAa

FAa= Franco-arcillo-arenoso

* Extracción con Acetato de Amonio pH=7.

** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 19.

Nombre del suelo: La Piñera.

Clasificación: Typic Tpopoudult.

Fecha de observación: 06-05-1986.

Ubicación: 5 Km antes del Río Volcán, Buenos Aires.

Altitud: 475 msnm.

Forma del terreno: Plano.

Pendiente: < 3%.

Uso de la Tierra: Piña.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Abanico aluvial del Valle del General.

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Ligera.

III. DESCRIPCION DEL PERFIL:

Ah 0-23 cm Rojo oscuro (2,5 YR 3/2) en húmedo; arcilloso; estructura en bloques subangulares y granular, fino y mediano, fuerte; friable, adhesivo y plástico; abundantes poros; abundantes raíces finas y muy finas; límmites difuso y plano; pH 5,8.

Bt1 23-70 Rojo amarillento (5 YR 4/6) en húmedo; arcilloso; bloques subangulares,finos y

		medianos, fuertes; abundantes poros; frecuentes recubrimientos de arcilla; pH 5,9.
Bt2	70+	Arcilloso; pH 5,7.

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PERFIL 19. LA PIMERA (BUENOS AIRES)

HORIZONTE	Ah	Bt1	Bt2
Profundidad cm	0-23	23-70	70+
pH H20	5,8	5,9	5,7
pH KCl	4,8	5,6	5,9
pH NaF	9,7	10,0	9,8
Cmol (+)/kg*			
Ca	2,5	2,3	2,5
Mg	1,4	0,6	0,5
K	0,14	0,16	0,17
CIC	19,3	17,7	13,3
SAT. BASES(%)*	20,9	17,2	23,6
Cmol (+)/kg**			
Ca	3,2	3,6	3,5
Mg	1,3	0,9	0,8
K	0,17	0,31	0,25
Acidez	0,5	0,2	0,3
CICE	5,2	4,9	4,8
SAT. BASES (%)**	90,4	95,9	93,8
SAT.ACIDEZ (%)	9,6	4,1	6,2
mg/kg			
P	2	2	2
Cu	12	13	8
Zn	3	3	3
Mn	39	17	7
Fe	21	19	13
MAT. ORG. (%)	3,02	0,34	T
% ARENA	23	17	23
% LIMO	19	13	13
% ARCILLA	58	70	64
NOMBRE TEXTURAL	A	A	A

A= Arcilloso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 10.

Nombre del suelo: Nazareth (Upala).

Clasificación: Typic Tropaquept.

Fecha de observación: 29-04-1986.

Ubicación: Puesto de vigilancia en Nazareth de Upala.

Altitud: 10 msnm.

Forma del terreno: Plano.

Pendiente: <3 %.

Uso de la Tierra: Frijol, bosque.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Aluvial.

Drenaje: Mal drenado.

Nivel freatico: 0,60 m.

Pedregosidad y/o rocosidad: No hay.

Erosión: No hay.

III. DESCRIPCION DEL PERFIL:

Ah1 0-8 cm Pardo grisáceo muy oscuro (10 YR 3/2) en húmedo; franco; estructura en forma de bloques subangulares medianos y fuertes; firme, no adhesivo ni plástico, ligeramente duro; abundantes poros y raices; límite abrupto y plano; pH 6,5.

Ah2 8-20 Pardo oscuro (7,5 YR 4/4) en húmedo; franco arcilloso; estructura en forma de bloques

subangulares, finos y medianos, fuertes; firme, ligeramente adhesivo y plástico; frecuentes poros finos y medios; frecuentes raíces; límite abrupto y plano; pH 6,8.

Bw1	20-36	Pardo amarillento oscuro (10 YR 4/4) en húmedo; arcilloso; bloques subangulares, finos y medianos, fuertes; firme, adhesivo y plástico; frecuentes poros muy finos, finos y medianos; pocas raíces finas; límite abrupto y plano; pH 6,7.
Bw2	36-52	Pardo grisaceo (10 YR 5/2) en húmedo; arcilloso.
C1g	52-82	Pardo grisaceo (10 YR 5/2) en húmedo; arenoso.
C2g	82-93	Griz (10 YR 5/1); arcilloso.

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PERFIL 10. NAZARETH (UPALA)

HORIZONTE	Ah1	Ah2	Bw1
Profundidad cm	0-8	8-20	20-36
pH H2O	6,5	6,8	6,7
pH KCl	5,6	5,2	4,9
pH NaF	8,7	9,2	9,1
Cmol (+)/kg*			
Ca	28,1	23,4	24,6
Mg	8,1	10,8	17,1
K	2,95	0,98	0,70
CIC	45,4	39,1	42,2
SAT. BASES (%)*	86,3	89,8	100,5
Cmol (+)/kg**			
Ca	25,0	22,8	27,1
Mg	5,5	7,5	10,4
K	2,46	1,03	0,51
Acidez	0,4	0,1	0,2
CICE	33,3	31,4	38,2
SAT. BASES (%)**	98,8	99,7	99,5
SAT.ACIDEZ (%)	1,2	0,3	0,5
mg/kg			
P	31	21	16
Cu	6	21	23
Zn	14	11	12
Mn	7	3	1
Fe	23	6	5
MAT. ORG. (%)	6,00	T	T
% ARENA	40	24	22
% LIMO	36	42	28
% ARCILLA	24	34	50
NOMBRE TEXTURAL	F	FA	A

F= Franco A= Arcilloso FA= Franco-arcilloso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

I. INFORMACION GENERAL ACERCA DE LA MUESTRA:

Número del perfil: 11.

Nombre del suelo: San José de Upala.

Clasificación: Oxic Tropoudalf

Fecha de observación: 29-04-1986.

Ubicación: Camino a San José de Upala, 3 km al norte del cruce.

Altitud: 70 msnm.

Forma del terreno: Ligeramente ondulado.

Pendiente: < 6 %.

Uso de la Tierra: Frijol, pastos.

II. INFORMACION GENERAL ACERCA DEL SUELO:

Material matriz: Planicie aluvial con influencia del Lago de Nicaragua.

Drenaje: Bien drenado.

Nivel freatico: Ausente.

Pedregosidad y/o rocosidad: No hay.

Erosión: Ligera.

III. DESCRIPCION DEL PERFIL:

A 0-25 cm Pardo fuerte (7,5 YR 4/6) en húmedo; arcilloso; estructura granular, fina y mediana, fuerte; firme, adhesivo y plastico, duro; abundantes poros de todo tamaño; abundantes raices; limite abrupto y plano; pH 6,1.

AB 25-43 Pardo (7.5 YR 5/4) en húmedo; arcilloso;

bloques subangulares, grandes y muy fuertes; muy firme, adhesivo y plastico, muy duro; pocos poros finos y medianos; frecuentes raíces muy finas; límite abrupto y plano; pH 5,8.

Bt1 43-100 Pardo fuerte (10 YR 5/3) en húmedo; arcilloso; estructura en blogues subangulares, fina y mediana, fuerte; firme, adhesivo y plastico, ligeramente duro; frecuentes revestimientos de arcilla; frecuentes poros finos y medianos; muy pocas raíces finas; pH 5,7.

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PERFIL 11. SAN JOSE DE UPALA

HORIZONTE	Ah	AB	Bt
Profundidad cm	0-25	25-43	43-100
pH H2O	6,1	5,8	5,7
pH KCl	5,2	5,0	5,3
pH NaF	9,0	9,0	9,3
Cmol (+)/kg*			
Ca	5,2	4,4	3,9
Mg	2,5	2,5	2,7
K	0,12	0,08	0,07
CIC	15,6	20,0	14,1
SAT. BASES(%)*	49,7	34,6	47,0
Cmol (+)/kg**			
Ca	5,2	4,9	4,0
Mg	2,3	2,3	2,5
K	0,88	2,10	0,87
Acidez	0,2	0,3	0,2
CICE	8,6	9,5	7,6
SAT. BASES (%)**	97,7	96,8	97,4
SAT.ACIDEZ (%)	2,3	3,2	2,6
mg/kg			
P	1	2	1
Cu	17	20	10
Zn	14	6	12
Mn	86	127	28
Fe	32	37	15
MAT. ORG. (%)	0,87	2,21	T
% ARENA	18	18	10
% LIMO	14	18	8
% ARCILLA	68	64	82
NOMBRE TEXTURAL	A	A	A

A= Arcilloso
* Extracción con Acetato de Amonio pH=7.
** Extracción con la solución Olsen modificada para K,P y elementos menores; y KCl 1N para Ca, Mg y acidez.

REPORT ON PROJECT AID-SCI 936-5442

Principal Investigator: Dr. Donald Kass,

Soil Management Specialist, CATIE

Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

Background:

The AID-SCI Project #936-5442 started on August 1, 1985. Dr. Kass is working on the identification of mechanisms for phosphorus absorption in Central American soils. These soils orginated from volcanic materials which are organically complex and often retain phosphorus. Plants generally require .2ppm phosphorus to develop to maturity. If the soil absorbs or fixes phosphorus there will not be enough of the mineral for the plant. Beans, an important food crop in Central America, are especially sensitive to phosphorus levels in the soil.

Traditionally, there are three treatments that can be applied if a soil is known to absorb phosphorus. First, the seeds or beans can be soaked in different phosphate solutions before planting and this will increase the phosphorus level in the plant. Second, there are foliar applications where phosphorus is directly applied to the leaf to increase the phosphorus level in the plant. The third treatment is to lime the soil.

Observations:

Dr. Kass is looking for the soil mechanisms that absorb phosphorus, so phosphorus will not need to be added externally to the soil or plant. The first step of his research is to characterize thirty different soils for

their mineral content. He has picked these thirty types and is currently running isotherms to determine the quantity of phosphorus absorbed by the soil and the plants. He is characterizing these thirty soils in cooperation with the USDA Soil Characterization Lab in Lincoln, Nebraska, which specializes in soil classification and consultation. Dr. Kass has also been able to utilize information from another USAID project - SMSS, (Soils Management Support System)—which has already characterized fifty different Latin American soils. All of this preliminary work is critical because volcanic soils have a lot of magnetic sand which makes them difficult to classify.

The next step of the research involves greenhouse screening of germplasm and application methods of phosphorus. This work is also in progress. A graduate student, Wilbert Campos Alvorado, is screening bean germplasm sent from CIAT, the Centro Internacional de Agricultura Tropical.

The final step will be field-testing the germplasm in the different types of soils. This will begin in September because that is when bean planting begins in Costa Rica. Field-testing will take place in Panama as well.

To date, Dr. Kass and his team have scientifically learned much about the mineralogy of soil. The problem of phosphorus fixation is much bigger than they originally thought. Many soils are fixing phosphorus so they had to limit the scope of their project. They also now can analyze clay fraction mineralogy by using ultrasound to separate the clays. The sound waves break the particles apart. A chemist at the University of San Jose, Dr. Bornemisza, is reinterpreting this data on the mineralogy of the soil. Together they have discovered a new mechanism for phosphorus retention in soils. Dr. Kass will present a paper on these results at the American Society of Agronomy - ASA meeting this December in New Orleans, Louisiana.

Conclusion:

After visiting Dr. Kass' lab and seeing his current work, I conclude that he is making satisfactory progress on his AID-SCI Project. There have been some administrative difficulties though. Although the Project officially started on August 1st, the funding was not available until November. CATIE has had some difficulty spending the allocated monies because half the funding is for the University of San Jose. There has also been some difficulty in getting a vehicle for field-testing, and some equipment has not been received. In view of these problems, Dr. Kass is doing well indeed. The only thing now needed is to identify a second graduate student for whom money has been budgeted, and to begin the field trials as scheduled in September. The Project will end in November 1988.

A copy of the Interim Progress Report No. 1, dated August 1, 1985 to May 1, 1986 is enclosed for your reference.

XN-AAZ-817-B

Interim Progress Report # 3

Nov.1, 1986-June 1, 1987

Project AID-SCI 936-5442

Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

I. RESEARCH PROGRESS

Most of the research activities proceded smoothly in this period. The plan of activities for 1987 was approved by ROCAP. Preliminary field experiments were successfully carried out at the CATIE station in Turrialba; an M.S. thesis on alternative methods of applying Phosphorus to beans was completed; soil samples were sent to the SCS laboratory in Lincoln, Nebraska for mineralogical analysis; P retention isotherms of the thirty soils specified in the project have been completed and these results correlated with other soil properties; and a second M.S. student began his research activities; and most of the sites for the field experiments to be carried out beginning in September, 1987, have been selected.

A.Field Experiments at CATIE

As a preliminary to the field experiments to be carried out on soils of different mineralogical characteristics in the final phase of the project, a prototype of these field experiments was planted at CATIE in January, 1987. As was pointed out in the previous interim report, the unavailability of the project vehicle, which finally did arrive in April, 1987, precluded field experiments at other sites in this period as originally proposed. Retention characteristics of the CATIE soil had been studied in

the M.S. thesis of Ing. Wilbert Campos; and the soil appeared to have the characteristics of P retention by both precipitation and adsorption mechanisms identified in the project as a characteristic of several Central American soils. Several of the treatments tested by Ing. Campos in the greenhouse were included in the field trial. One experiment was a 3X 2^4 factorial with the factors bean variety, liming, fertilizer P, foliar P, and P applied by seed imbibition. A single replicate was used and the third and fourth order interactions used to estimate error. The analysis of variance and significant effects and interactions are given in Table 1. Varieties, liming, and P application (300 kg ha^{-1} P)gave significant positive effects on bean yield. P imbibition had a significant negative effect. The interactions, imbibition X varieties, imbibition X liming, and imbibition X P were all significant. These interactions, summarized in Tables 1a, 1b, and 1c show that in the absence of liming and P fertilization, seed imbibition of Phosphorus (3 hours in a solution of K_2HPO_4, containing 8000 ppm of P) did increase bean yields, showing that the practice may have some validity where neither liming nor P fertilization is feasible. Despite the use of only one replicate, precision was acceptable (C.V. =19.87%). Foliar samples of the beans are presently being analyzed and will be used for a more complete evaluation.

The second experiment combined a complete factorial (2^3 (liming, foliar P, and seed imbibition) with five levels of fertilizer P (0, 150, 300, 450, and 600 kg ha^{-1} of P) in a split plot experiment with two replicates. Thus, considerable precision was available for the P response curve which could be combined with the P adsorption isotherms to determine external P

Table 1. Analysis of Variance and Principal Significant Effects of the 3 X 2^4 Experiment

Source of Variation	DF	SS	MS	F
Varieties	2	2115430	1057915	17.97**
Liming	1	308481	308481	5.24*
Soil P application	1	5923480	5923480	100.6**
Foliar P	1	138675	138675	2.35(n.s.)
Seed imbibition of P (IMB)	1	639870	639870	10.87**
Vars X Liming	2	25647	12823	0.21 (n.s.)
Vars X Soil P	2	466362	233181	3.96*
Vars X Fol. P	2	827	414	0.007 (n.s.)
Vars. X Seed P	2	633244	316622	5.37*
Liming X P	1	29601	2960	0.50
Liming X Foliar P	1	850	850	0.014
Liming X Seed P	1	389520	389520	6.61*
Soil P X Foliar P	1	2523	2523	0.04
Soil P X Seed P	1	420751	420751	7.14*
Foliar P X Seed P	1	54675	54675	0.92
Residual	27	1589072	58854	

1a. Varietal Effects (kg/ha beans at 14% moisture)

VARIETY	Mean Yield	Effect of Soil P		Effect of Seed Imbibition	
		-P	+P	-Imb	+Imb
ICA Pijao	1519	1036	2001	1746	1291
IGUACU	1046	719	1373	1207	885
PUEBLA 152	1108	863	1352	1065	1149

1b. Main Effects (kg/ha beans at 14% moisture)

-IMB	1339	-P	873	-Liming	1144	-Foliar P	1278
+IMB	1109	+P	1576	+Liming	1304	+Foliar P	1170

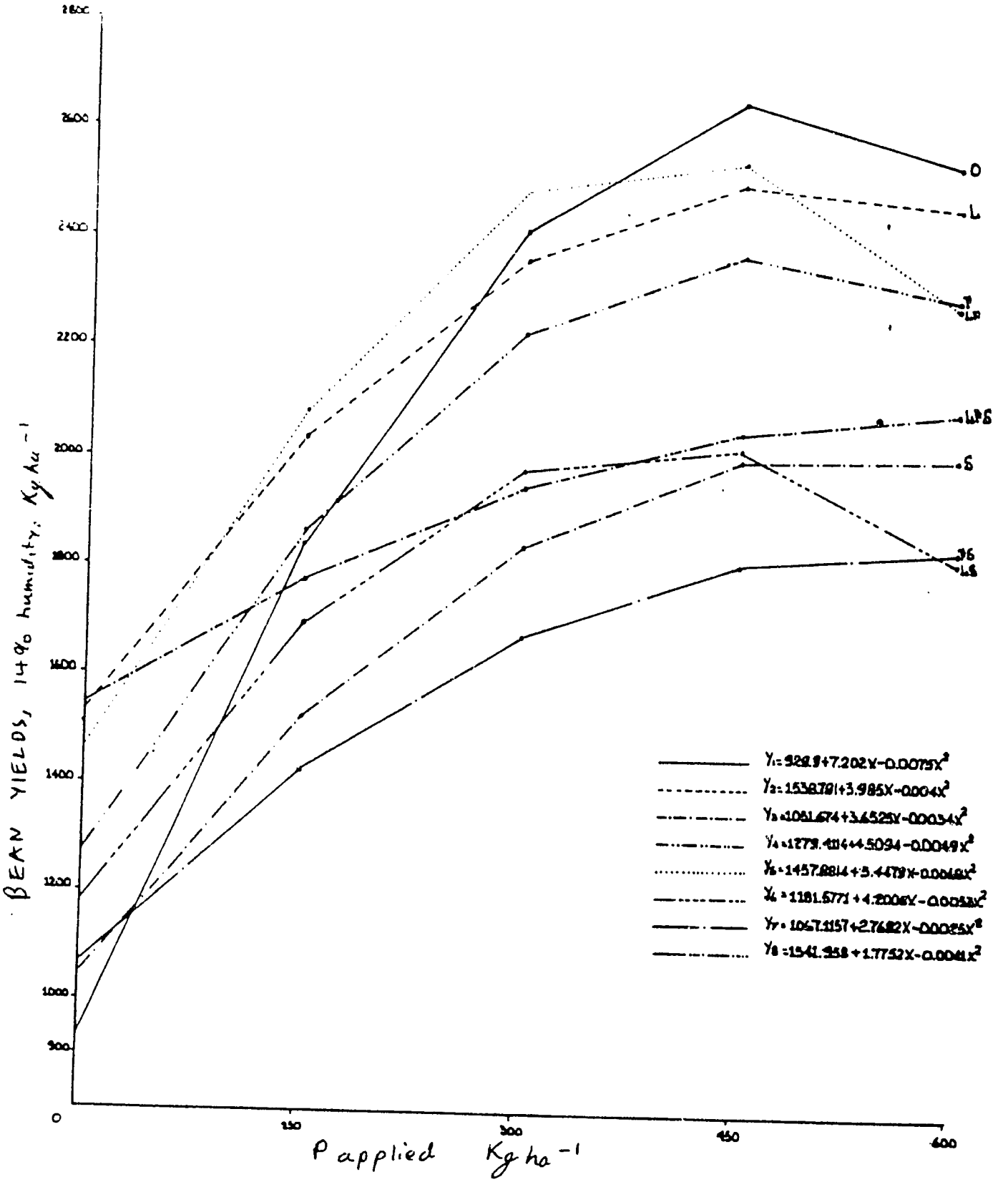
1c. Liming Effects (kg/ha beans at 14% moisture)

	-IMB -Soil P	+IMB -Soil P	-IMB, + Soil P	+IMB, + Soil P
No Lime	671	874	1668	1373
With Lime	1118	838	1902	1360

50

requirements using the method of Fox (1981). External P requirement for the ICA-Pijao variety without soil amendments or seed treatment was found to be 0.084 ppm P in the soil solution which compares well with the value of 0.08 reported for the ICA-Huasano variety by CIAT (1977) in Colombia on a soil of volcanic origin, like the one used in the present study. Interpretation of the effect of liming is complicated by the fact that liming shifted the P adsorption isotherm upward as was found by Friesen, Juo, and Miller (1980) on a Nigerian Ultisol with similar levels of exhangeable aluminum as the soil used in the present study. However, the level of fertilizer P required for 95% of maximum yield is lower with liming as is generally reported in the tropics (Lathwell, 1979) so that when the response curve is combined with the isotherm in order to determine the external P requirement, (Figure 2) , the latter is found to be 0.089 ppm , higher than in the absence of liming. Though this result may not at first seem reasonable, it should be remembered that liming increases the amount of P in the soil solution. Hence, there will be a higher level of soil solution P at all levels of applied P in the limed plots. It should be noted that Friesen et al. observed this effect only at higher levels of lime application as were used in the present study (5 t ha^{-1})

As can be seen in Figure 1, the effect of foliar P application and seed- imbibition increased the intercept value of the response curve but decreased the slope. A combination of liming with foliar P or seed imbibition reduced considerably the amount of P required to obtain maximum yield and consequently reduced the external P requirement somewhat.



RESPONSE OF BEANS ICA-PIJAO TO PHOSPHORUS WITH DIFERENT COMBINATION OF LIME, FOLIAR APPIED P. AND SEED-IMBIBED P. TURRIALBA, 1987

In Figure 2, percent maximum yields are plotted against P levels in the soil solution as calculated from the isotherms for limed and unlimed soil for four treatments (Control, liming, seed imbibition, and foliar P application). The curves for the remaining four treatments are presented in Figure 3.

All of the values for the external P requirement only vary from 0.082 to 0.093 ppm, which appear to be quite reasonable. Lower values might be found if the soil is allowed to react with the fertilizer P for a longer period as was found by CIAT in the second year of the experiment referred to above(CIAT, 1978).

B. M.S. Thesis of Wilbert Campos.

A M.S. thesis based on the greenhouse screening component of the project was submitted to the CATIE-University of Costa Rica graduate program by Ing. Wilbert Campos, who received a scholarship from the project. The thesis was entitled "Manipulacion del cultivo del Frijol (Phaseolus vulgaris L.) para superar diversos mecanismos de retencion de fosforo en suelos de Centroamerica". Ing. Campos worked with four bean varieties (Rio Tibaji and Iguacu, selected by CIAT as being tolerant of low soil Phosphorus levels and ICA Pijao and Puebla 152, considered intolerant) with three soils: an Ultisol with high levels of exchangeable aluminum, an Andept with high levels of amorphous aluminum, and a Humitropept with high levels of both exchangeable and amorphous aluminum.

There were three phases to the study. In the first, the effect of drying and liming on different physical and chemical characteristics of the three soils was studied. the amounts of nutrients necessary to achieve desirable levels in each of the soils was studied. P retention isotherms were determined for each

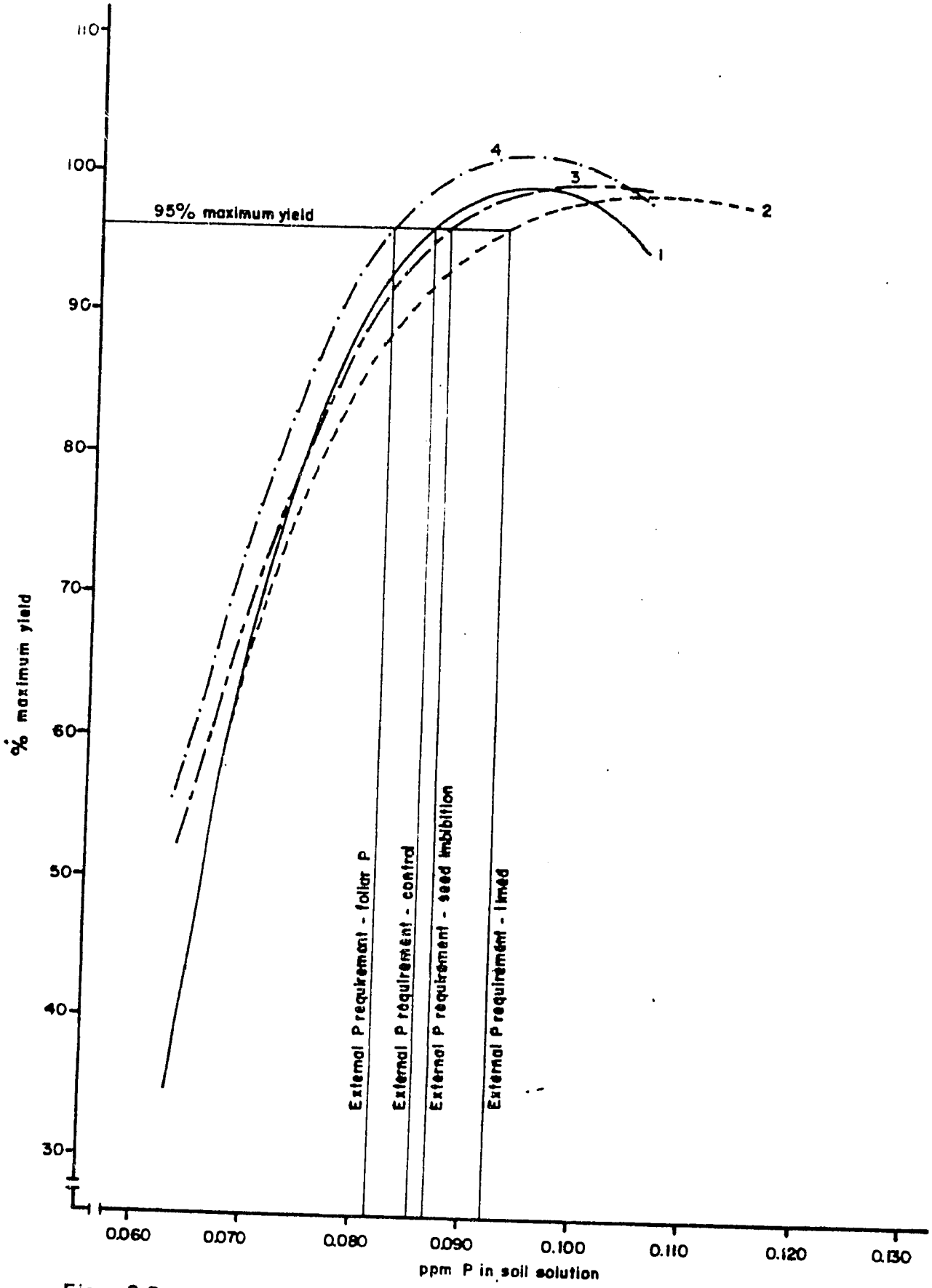


Figure 2 Determination of external phosphorus requirement of beans under four management systems

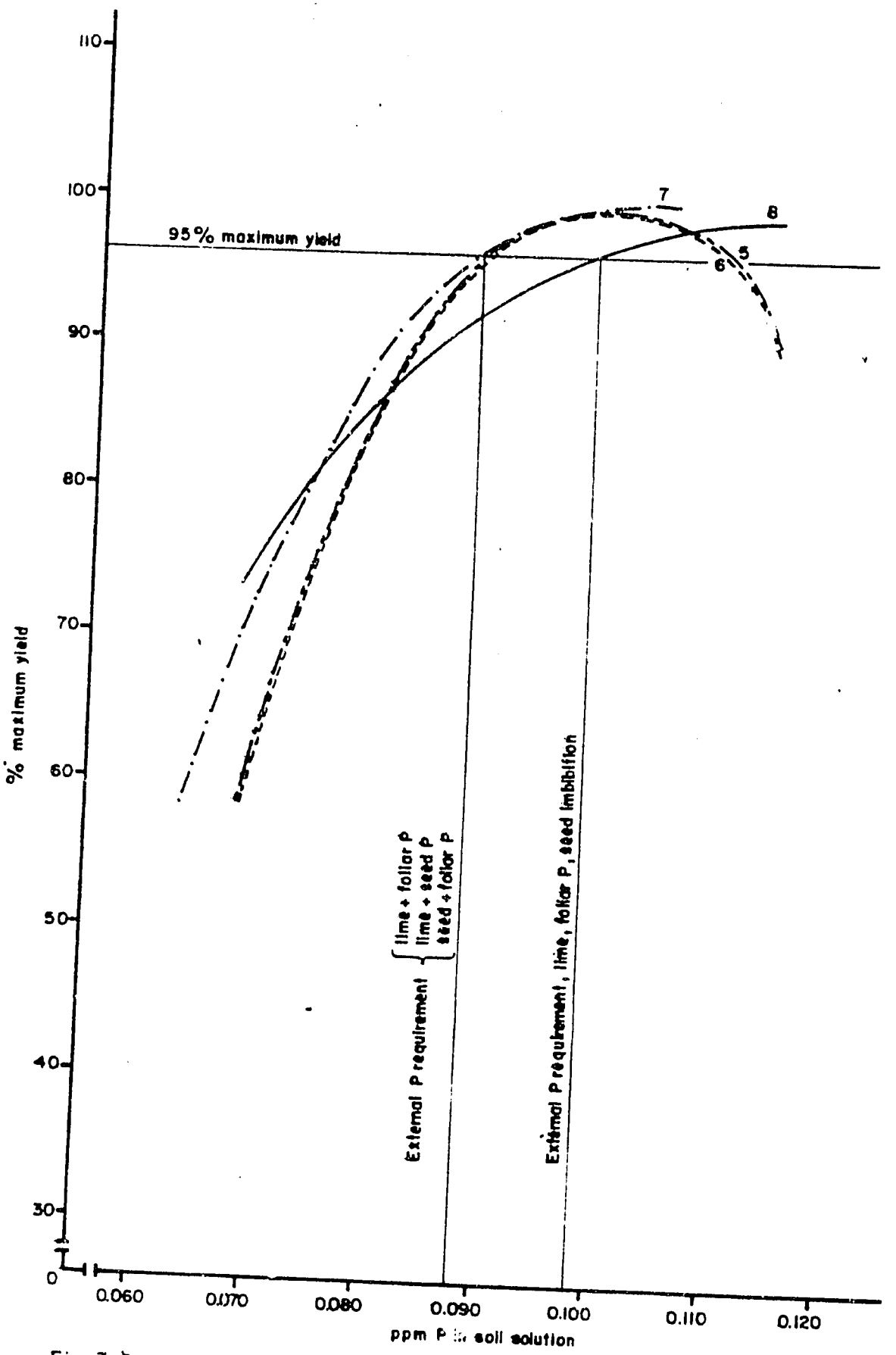


Fig. 3 Determination of external phosphorus requirements of beans with combinations of liming, seed imbibition, and foliar P

soil in the wet and dry and limed and unlimed states.

In the second phase different formulations and concentrations of phosphorus containing solutions as well as times of imbibition were evaluated to determine the P-source, concentration, and imbibition time which most increased P content without decreasing viability.

The third phase was a greenhouse experiment in which liming, four bean genotypes, and foliar and seed imbibed P application were evaluated in each of the three soils.

Principal results of the study were as follows:

1) Drying affected soil physical properties, such as texture, more than chemical properties, such as P retention

2) P retention of all three soils was quite high, about 90% as determined by the isotherms.

3)Highest increase of P content of the seed and germination was achieved by imbibition for three hours of a solution of potassium phosphate (K_2HPO_4), containing 8000 ug/ml P.

4) Liming was especially effective in increasing P uptake in beans in soils with high levels of exchangeable aluminum. It has less effect in soils with more andic properties, containing low levels of exchangeable aluminum.

5) There were differences among genotypes in P uptake from soils receiving the same treatment.

6) Seed imbibition increased P utilization by the plants while foliar application tended to reduce it.

. Mineralogical Analyses of Soil Samples by SCS Laboratory in Lincoln, Nebraska

During the months of November and December, 1986, the agronomist paid by the project worked at the destruction of organic matter and separation of clays on 90 samples, representing 90 horizons of the thirty soils identified by the project for which mineralogical characterization did not exist. Following contacts made with Dr. J. Kimble of the SCS laboratory in Lincoln, Nebraska, the prepared samples as well as unaltered samples of the same soils were sent to the SCS laboratory through the kind services of Dr. Madison Wright of Cornell University who hand carried the samples to the U.S. Dr. Kimble acknowledged receipt of the samples in February, 1987, and said there would be no difficulty in completing the required characterizations byAugust, 1987. We have not yet had any further word from Dr. Kimble although, following instructions of Dr. Hari Eswaran, of SMSS, he sent us characterizations of some 25 other soils, from Panama and Nicaragua, which will be of great use in determining the occurrence of mineralogical characterics identified as important in the project. There is a very good possibility that Dr. Ray Bryant of Cornell University will be available as a consultant to the project from January to June, 1987. He will work on correlating the mineralogical information with other soil characteristics. This information will be of great use not only to the project but also to SMSS.

b. Correlation of P retention with other soil characteristics.

Working with some 37 soils which are being characterized by the project, the chemist from the University of Costa Rica, who is one of the participants in the project, carried out ten different determinations of properties which were then correlated with P retention as determined by isotherms and the New Zealand P retention determination. These results are presented in Tables 3 and 4 for all thirty seven soils and for the twenty soils classified as Andepts respectively. Soil pH determined in NaF correlated best with P retention by both methods for both groups of soils although use of this measurement in non -Andepts has been criticized (Kimble,Holzhey, and Holmgren, 1984). Aluminum extracted by acid oxalate, which has been considered a better measure of amorphous aluminum correlated better with New Zealand P retention than with isotherm-determined P retention. Strangely, the correlation with P retention by isotherms improved somewhat while that with New Zealand P retention decreased somewhat when only Andepts were considered. A reverse trend was shown for citrate-dithionate Aluminum which gave higher correlation in andepts with New Zealand P and lower correlations in andepts with isotherm P. A similar trend was shown for aluminum extracted in 4 N KOH, which is supposed to characterize andic properties better than NaF (Kimble et al.,1984) although it did not correlate well with P retention by the isotherms for the soils described as Andepts. Further analyses of this data will be carried out using multiple regression techniques. It would seem that the pH in NaF and Al determined in acid oxalate are the best predictive measures of P retention. The two determinations were more highly

TABLE 3. CORRELATION FOR ALL SOILS

	% M.O	pH NaF	Al Oxalato	Al citrato-dithionito	Al Pyrofosfato	Al KOH	Fe Oxalato	Fe citrato-dithionito	Fe Pyrofosfato	Reider Intercambio
% New Zealand P-retention	0.6165**	0.8563**	0.8402**	0.6851**	0.3427	0.6306**	0.5902**	−0.811**	−0.3286	−0.6859**
% M.O	—	0.7233**	0.5488**	0.6660**	0.4279*	0.5364**	0.5379**	−0.7533**	−0.1041	−0.6303**
pH NaF	—	—	0.8325**	0.8030**	0.5109**	0.7630**	0.6455**	0.8520**	−0.1906	−0.6743**
Al Oxalato	—	—	—	0.6856**	0.3317	0.7519**	0.6916**	−0.8016**	−0.3217	−0.6319**
Al Citrato-dithionito	—	—	—	—	0.7110**	0.8882**	0.4838**	−0.6772**	0.1421	−0.6461**
Al Pyrofosfato	—	—	—	—	—	0.6406**	−0.3055	0.2578	0.5258**	−0.4722**
Al KOH	—	—	—	—	—	—	0.4970**	0.5520**	0.0541	−0.7041**
Fe Oxalato	—	—	—	—	—	—	—	0.5337**	−0.1939	−0.5660**
Fe Citrato-dithionito	—	—	—	—	—	—	—	—	0.2578	0.6747**
Fe Pyrofosfato	—	—	—	—	—	—	—	—	—	0.0453
% P retention isotherms	0.4383*	0.7462**	0.5370**	0.5890**	0.4098*	0.5574**	0.5793**	0.4471*	0.094	−0.3587*

TABLE 4 CORRELATIONS FOR SOILS CLASSIFIED AS ANDEPTS

	% M.O	pH NaF	Aluminio Oxalato	Aluminio Citrato-dithionito	Aluminio Pyrofosfato	Aluminio KOH	Fe Oxalato	Fe Citrato-dithionito	Fe Pyrofosfato	Acidez Intercambiable
% P-retenido Nueva Zelanda	0,4471*	0,8901**	0,8155**	0,7829**	ns	0,7062**	0,5396*	−0,7933**	0,071	−0,7439**
% M.O	—	0,6003**	0,2853	0,5974**	0,3247	0,3053	0,2727	−0,6429**	0,1121	−0,4815*
pH NaF	—	—	0.8024**	0.9134**	0.5755**	0.7419**	0.4220	0.8410**	0.0564	0.6114**
Al Oxalato	—	—	—	0.7180**	0.3246	0.8051**	0.5823**	−0.6450**	−0.1612	−0.5737**
Al Citrato-dithionito	—	—	—	—	0.6659**	0.8140**	0.2408	−0.7251**	0.2133	0.5549*
Al Pyrofosfato	—	—	—	—	—	0.5226**	0.0675	−0.3895	0.6299**	0.4361
Al KOH	—	—	—	—	—	—	0.2372	−0.5100*	0.0899	−0.6256**
Fe Oxalato	—	—	—	—	—	—	—	−0.2797	0.2692	ns
Fe Citrato-dithionito	—	—	—	—	—	—	—	—	0.8635	0.6577**
Fe Pyrofosfato	—	—	—	—	—	—	—	—	—	0.0467
% P-retenido Fresh Isotherms	[illegible]	[illegible]**	[illegible]**	0.4876*	0.2370	0.3343	0.5737**	−0.5118*	−0.1618	−0.3855

correlated (r = 0.86) in all 37 soils than in just the Andepts (r = 0.80).

E. M.S. Thesis of Alexis Samudio

The other student who receives a scholarship from this project has begun his thesis work using a soil from the Caizan region of Panama, which is the major bean-growing area of that country. The soil has andic properties, relatively, low-levels of exchangeable aluminum and moderate levels of P retention. Ing. Samudio , who is of Panamanian nationality, will determine external P requirements of four of the most important Panamanian bean varieties. He will precede this work with greenhouse studies to determine response of these varieties to different lime and phosphorus levels as well as foliar and seed imbibed P. Soil was brought from Panama in April, 1987. Greenhouse work will begin in July. Field experiments will begin in October, 1987, which corresponds to the planting date in that region of Panama. Preliminary test have shown the soil to be low in zinc. Effect of zinc and incorporation of lime on P response of beans will be determined under field conditions.

F. Other field experiments.

Field experiments similar to the ones carried out in Turrialba and planned for Panama are scheduled to be planted beginning in September, 1987,in the following sites: San Isidro, San Vito, Fraijanes, Rio Frio, Puriscal, San Carlos. Experimental areas belonging to the University of Costa Rica and the Costa Rican Ministry of Agriculture are available at most of these sites.. Planting dates for beans vary somewhat, from September

to December, over these sites.

II. Changes in Research Plans.

As noted above, progress was very much as expected during this period so that no changes in research plans should be necessary. Field experimentation should begin on schedule in September. While there might be some delay in the receipt of the mineralogical analyses from the laboratory in Lincoln, this should not result in any change in programmed activities.

The very good possibility that Dr. Ray Bryant of Cornell University will be able spend his sabatical at CATIE, partially financed by the project should help in the final write-up of the research results. Hopefully, he will be able to integrate the existing information on soils in the region with the findings of the project. The receipt of more soil analyses from SMSS will somewhat enhace the scope of the project because there is apparently more information available than was originally thought.

The arrival of the project vehicle has been a great help in carrying out diverse activities. However, there have been some unanticipated expenses associated with insuring the vehicle and obtaining another set of keys when the originals disappeared from the vehicle while it was parked in the CATIE garage.

The laboratory equipment ordered by the project has arrived in Costa Rica and should be released from customs by the end of August, 1987, one year after it was ordered.

A more serious problem, mentioned in the previous report, is the increase in the cost of maintaining a student at

CATIE. The money budgeted for student scholarships will not be sufficient to support Ing. Samudio until the termination of his thesis research. More funds are being sought from PSTC for this purpose but efforts so far have not met with any response.

III. BENCHMARK DATES

July, 1987	Wilbert Campos takes final thesis exam Alexis Samudio begins greenhouse experiment
August, 1987	Mineralogical results received from SCS Alexis Samudio submits thesis proposal
September, 1987	Greenhouse study terminated Alexis Samudio takes admission to candidacy examination Field experiments planted in Pursical and San Isidro
October, 1987	Field Experiments planted in Panama and San Vito.
November, 1987	Field experiments planted in Rio Frio and Fraijanes Fourth Interim report and workplan for 1988 submitted to ROCAP
December, 1987	Field Experiments planted in Turrialba and San Carlos Experiments in Puriscal and San Isidro harvested
January, 1988	Experiments in Panama and San Vito harvested.

Arrival of Dr, Ray Bryant

March, 1988 All field experiments harvested

April, 1988 Analysis of results for final report begins.

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