USE OF INDIGENOUS PHOSPHATE ROCK FOR ALUMINUM-TOLERANT SOYBEAN CULTIVARS IN HUMID TROPICAL SOILS

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Fourth Technical Quarterly Report for the Period July to September 1992

Following are brief explanations at the project activities that have occurred chronologically.

1. The first green house study which was started late June had to be terminated because of high aluminum (Al) and manganese (Mn) toxicities. These varieties were considered to be adaptable to tropical regions and should tolerate pH as low as 4.2. Soybean plants were not showing good growth, therefore we harvested the plants and dry matter was taken; the experiment will be repeated next march.

2. A Lime requirement determination will be made by constructing a pH vs. $MgCO_3$ level curve to find out the exact amount of lime needed to increase the pH to about 5.2 before the second green house experiment.

3. Drs. Robert W. Taylor and S.H. Chien traveled to Colombia South America to set up the field study. They met the Colombian government agriculturalist and selected the person who would carry out the experiment. They hand carried about 40 pounds of soybean seeds (two varieties) from U.S.A. which will be tested along with a local variety in the field experiment. The reports are attached and this constitute part of this quarterly report.

4. Results of the incubation study were presented in the Ninth Biennial Research Symposium sponsored by the Association of Research Directors in Atlanta, GA, November 4-11. Complete results of the incubation study is included in this report.

ABSTRACT

The direct application of indigenous Phosphate Rock (PR) is an economically feasible alternative to the use of more expensive water soluble P fertilizers in some developing countries especially in the humid tropical regions. The objective of this incubation study which was a prelude to greenhouse and field studies was to evaluate the chemical changes in relation to the effectiveness of three PRs (Pesca, Huila and Sechura) from humid tropic regions relative to water-soluble Triple Super Phosphate (TSP) in three soil types, two from Colombia South America (Oxisol and Inceptisol) and one from USA (Hartselle soil). Three P rates of 100, 200 and 400 mg kg^{-1} were mixed with 100g soil of each type. Samples were taken for analysis at four incubation times up to 10 weeks in duplicate. pH, available P, exchangeable Ca, Al, and CEC were determined. In general, the pH of the soils increased after one week of incubation, then generally decreased gradually especially by week six. Aluminum decreased significantly through the six weeks and at the same time Ca increased significantly; this is in agreement with the previous reported work that the direct application of PR will increase the pH and Ca, and at the same time reduce exchangeable Al. Available P increased by the first week then gradually decreased. In general, the reduction in Al and increase in pH and Ca will give a possible beneficial effects on the direct application of PR on acid tropical soils for crop production.

INTRODUCTION

Phosphorus (P) is one of the most limiting nutrient for crop production especially in acid tropical soils. Some of the tropical soils have high P-sorption capacities which makes successful crop growth more difficult in an already P-deficient soil. Adequate P fertilization is therefore essential for economic and sustainable crop production (Menon, et al., 1991). Due to the high cost of P fertilizers, the use of conventional water-soluble P fertilizers has been limited especially for those countries which have to import fertilizers. Phosphate Rock (PR) deposits occur in several countries of Asia, Africa, Latin America, and even in some parts of United States. Some of these PRs are chemically reactive and can be used effectively as a substitute for the expensive P fertilizers especially in acid soils (Leon, et al., 1986; Hammond et al., 1986). Some of these PRs have low chemical reactivity and perform poorly, especially when used for crop with short growing seasons. Partially acidulated PRs are as effective as superphosphate for certain crops (Hammond, et al., 1986; Chien and Hammond, 1989).

The objective of this incubation study which was a prelude to greenhouse and field studies to evaiuate the chemical changes that occurred in relation to the effectiveness of three PRs (Pesca, Huila and Sechura) from humid tropic regions relative to Triple Super Phosphate (TSP) in three soil types-two from Colombia South America and one from USA.

MATERIALS AND METHODS

Three soil types were selected for this incubation study, two from Colombia South America (Inceptisol and Oxisol) and Hartselle silt loam from USA. The Inceptisol and Oxisol had pH of 4.5 and 4.9 respectively, while the Hartselle soil had pH of 4.5. All three soil were low in phosphorus content (<2 ppm) and had over 70% aluminum saturation. The P content of the phosphate rocks and TSP are as follow: Pesca and Huila 8.7%, Sechura 13% and TSP 21%. Three Phosphate Rocks (PR), Pesca and Huila from Colombia and Sechura from Peru South America and water-soluble Triple Super Phosphate (TSP) were used as P sources. The P content of the phosphate rocks and TSP were as follow: Pesca and Huila 8.7%, Sechura 13% and TSP 21%. Three P rates of 100, 200 and 400 mg/kg were mixed with 100 g soil of each type. The finely ground PRs were mixed with ground soil (passed through 2 mm sieve), watered to field capacity (20%) and incubated at 30°C. Samples were taken in duplicate for chemical analyses up to 10 weeks (initial, one week, three weeks, six weeks and 10 weeks). pH, P, exchangeable Ca, Mg, K and Al, CEC and percent Base Saturation (%BS) were determined at each sampling time.

RESULTS AND DISCUSSION

The three soil types treated with PRs and TSP generally showed the same trend in pH changes during the 10-week incubation study (Fig. 1, and 9). pH increased during the first 10 days and then generally decreased until 6 weeks. Hartselle silt loam and Colombian Oxisol had higher pH after 10 weeks of incubation than their initial pHs. Colombian Inceptisol had slightly lower pH than the initial pH after 10 weeks especially with Pesca and TSP treatments. Hammond, 1979 reported that Phosphate Rock will increase the pH up to 0.4 unit, however our data shows the increase is much higher especially early after application. pH changes in all soils followed the same trend with different rates of PRs and TSP. Phosphate was measured by recently developed method (Pi method) by International Fertilizer Development Center (IFDC) (Mennon, 1989). phosphate changes in Inceptisol and Oxisol followed the same trend in all treatment, however P in the TSP treatments decreased sharply by the first week then stabilized throughout the study. P changes in Hartselle Soil was very erratic with all the PRs and TSP treatments. (Fig. 2, 6 and 10). Among the PRs, Sechura PR treated soil had higher P at any time followed by Huila and Pesa, this is in direct relationship with their chemical reactivity which follow the same trend as Sechura>Huila>Pesca. Exchangeable Al decreased sharply through the first 3 weeks in all soils. This is attributed to the increase in pH in the first week of incubation (Fig. 3, 7 and 11). Sechura and Huila PRs treated soil reduced the exchangeable Al more than Pesca and TSP. Chien, 1982 reported that exchangeable Al reduced through the 9 weeks then stayed the same until week 15 in an incubation study in greenhouse. Our data indicate that exchangeable Al at first decreased and then increased sharply in all treatments after week three. Exchangeable Ca increased sharply during the first week of incubation then decreased up to six week in all three soils (Figs. 4, 8 and 12) Huila and Sechura PRs treated soil increased the exchangeable Ca more than Pesa and TSP. Generally, the same trend was observed in all treatments, when pH increased, exchangeable Al decreased and Ca increased. The reduction in exchangeable Al and increased in pH and exchangeable Ca will give a possible beneficial effects on the direct application of phosphate rocks especially if more chemically reactive kind is used on acid tropical soils for crop production.

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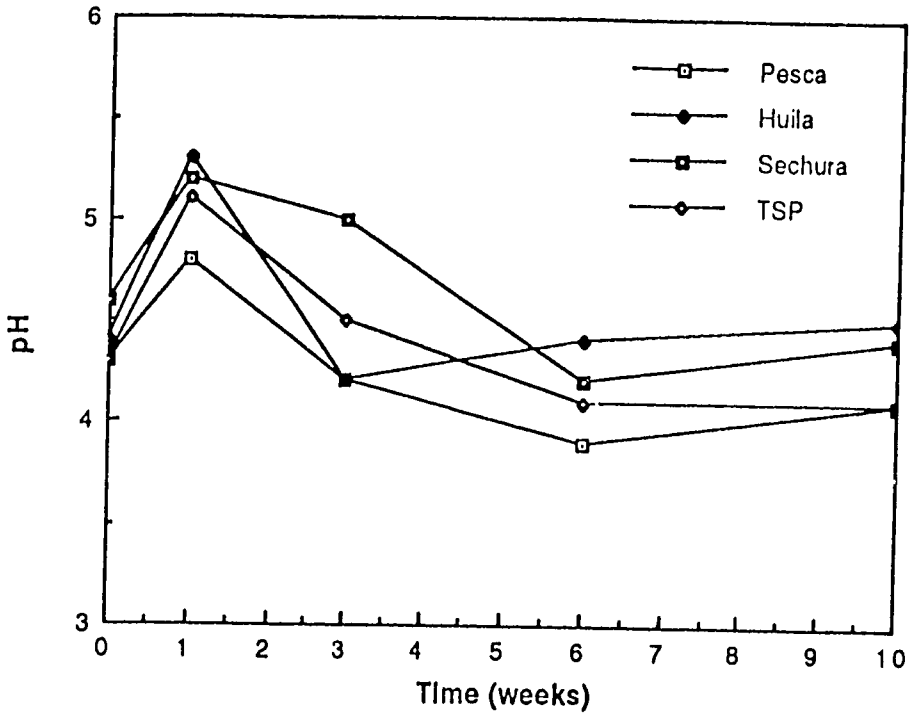

Fig.1 pH changes in a Colombian soil (Inceptisol) treated with four different P sources during 10-week incubation study

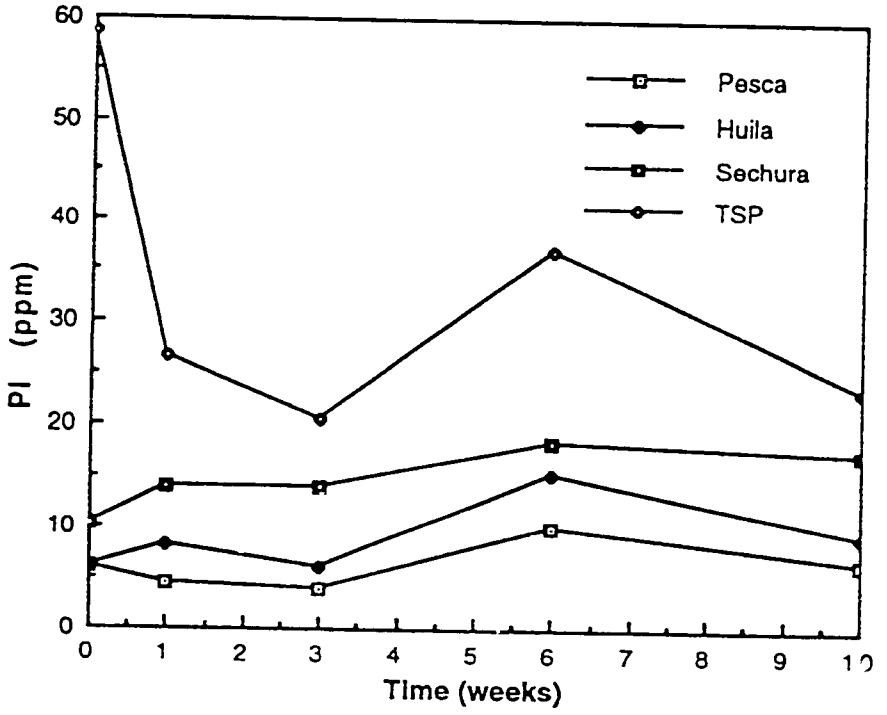

Fig.2 Pi changes in a Colombian soil (Inceptisol) treated with four different P sources during 10-week incubation sudy

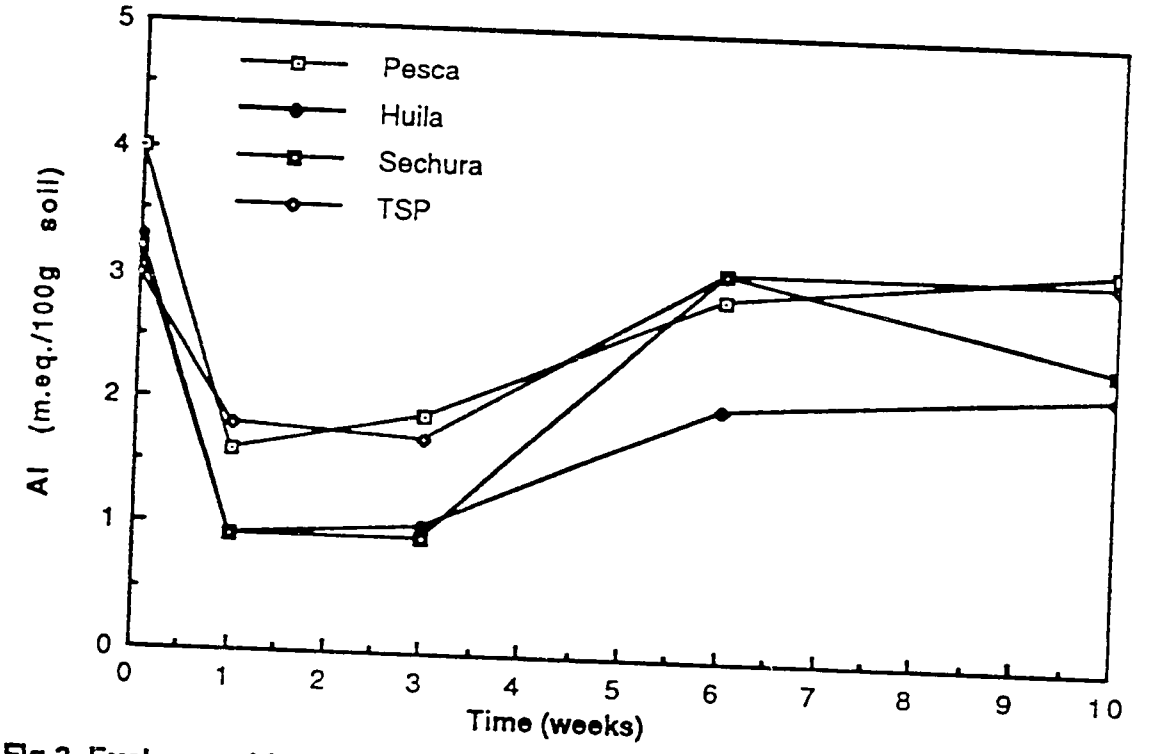

Fig.3 Exchangeable Al in a Colombian soil (Inceptisol) treated with four different P sources during 10-week incubation study

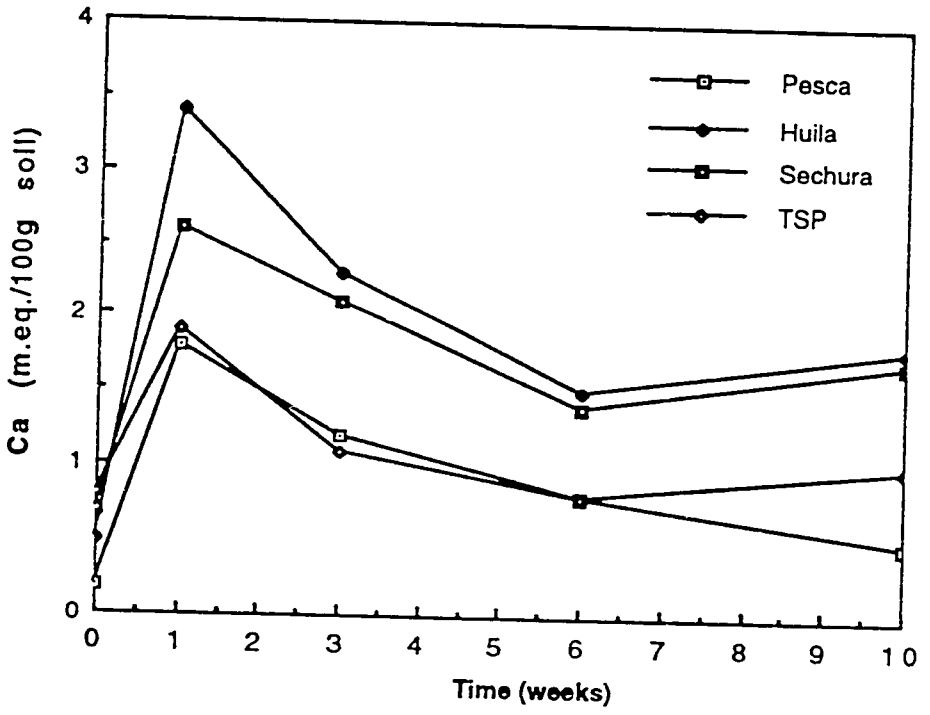

Fig.4 Exchangeable Ca in a Colombian soil (inceptisol)treated with four different P sources during 10-week incubation study

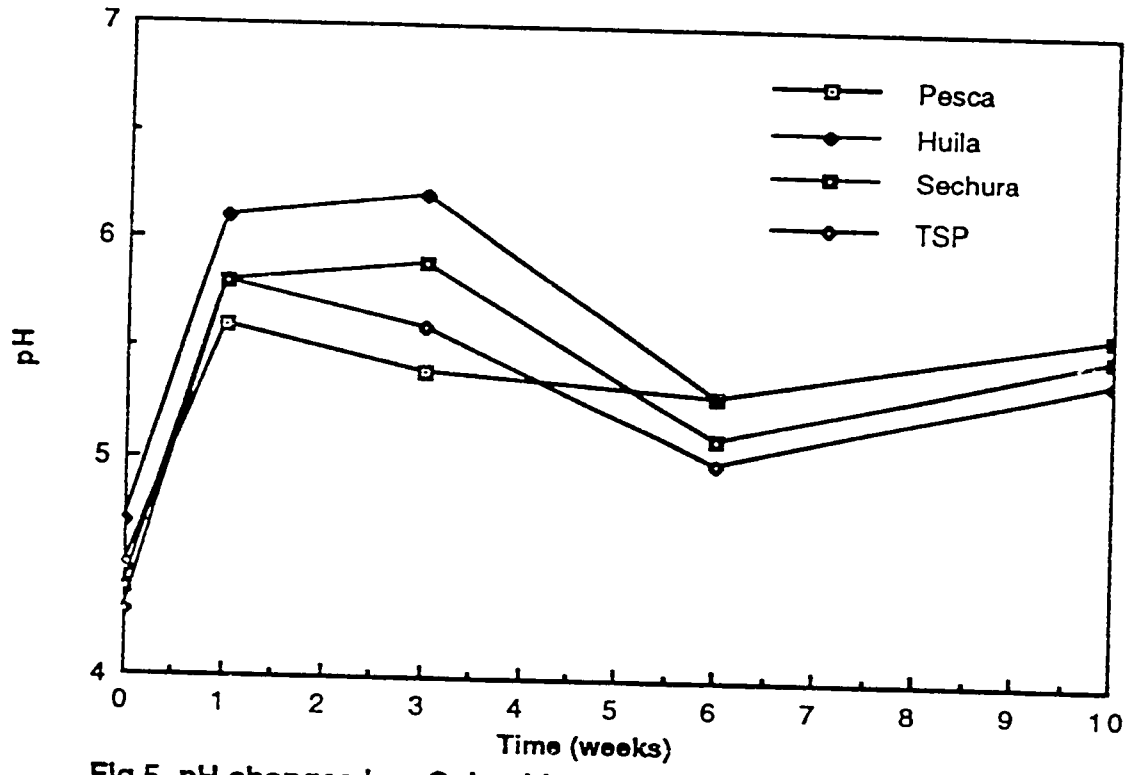

Fig.5 pH changes in a Colombian soil (Oxisol) treated with four different P sources during 10-week incubation study

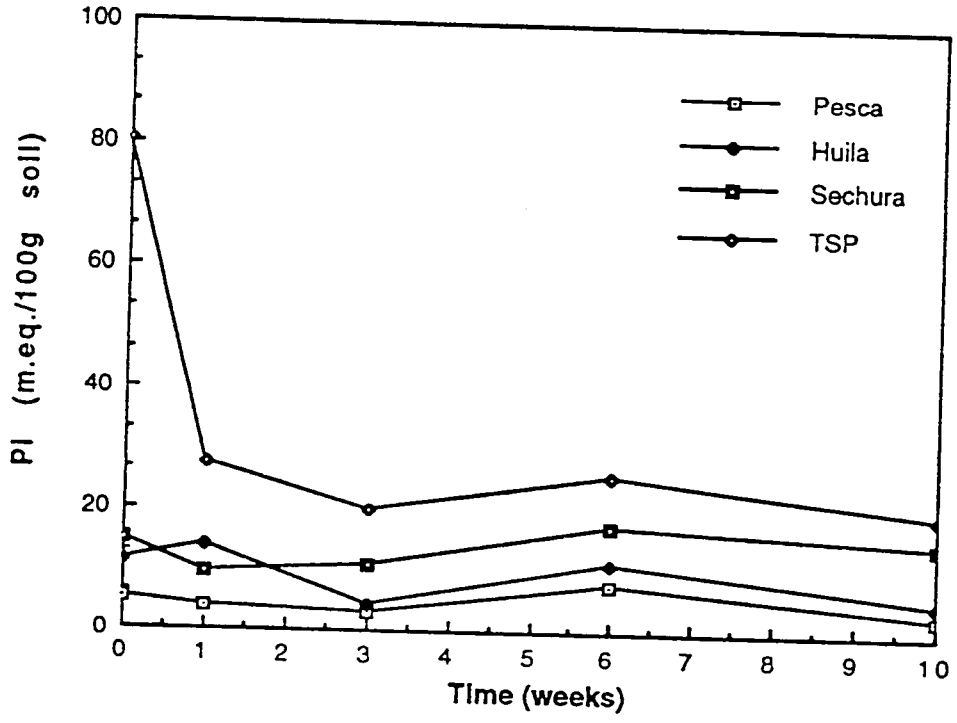

Fig.6 PI changes in a Colombian soil (Oxisol) treated with four different P sources during 10- week incubation study

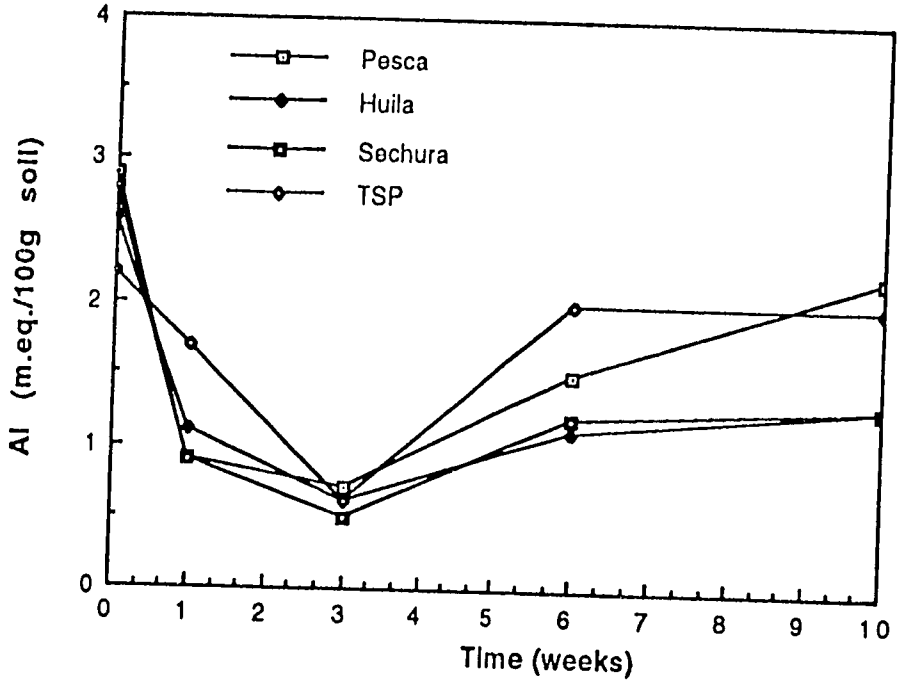

Fig.7 ExchangeableAl in a Colombian soil (Oxisol) treated with four different P sources during 10-week incubation study

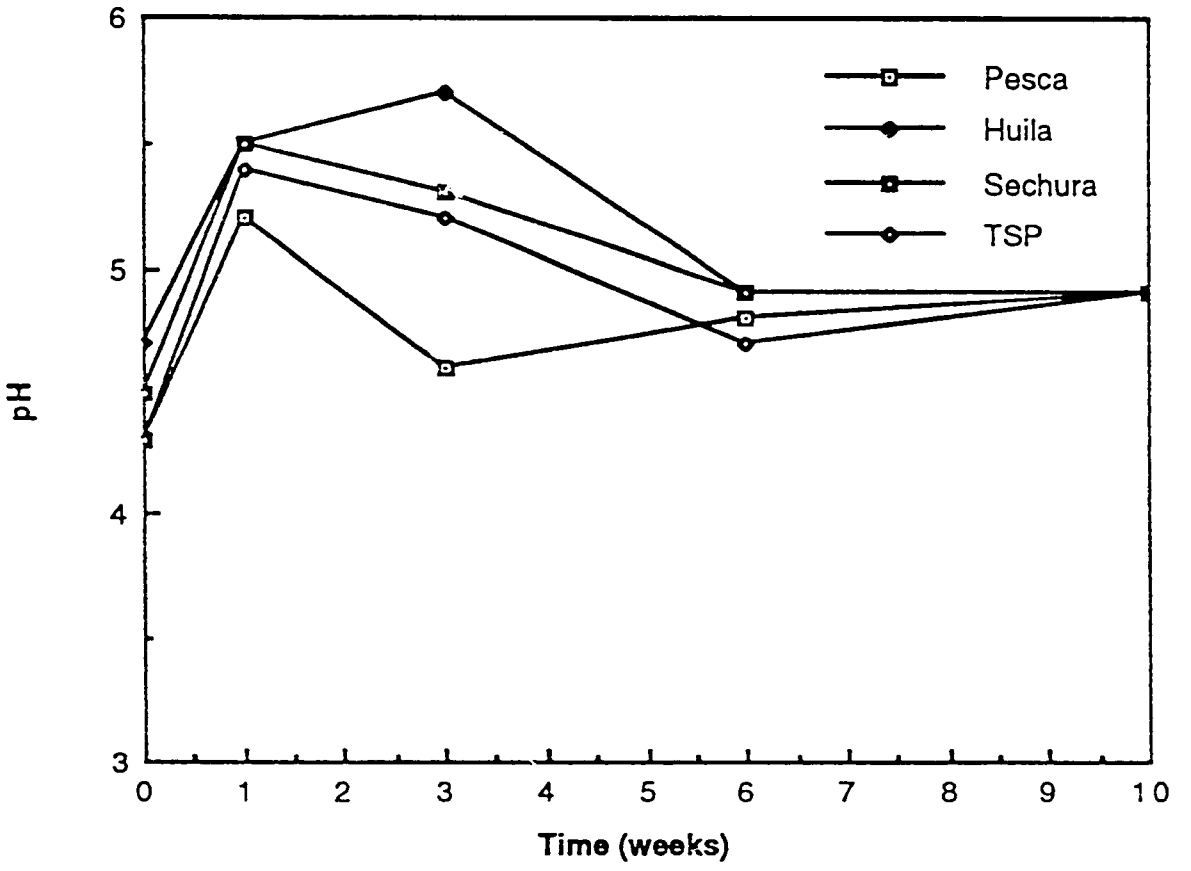

Fig.9 pH changes in a Hartselle soil treated with four different sources during 10-week incubation study

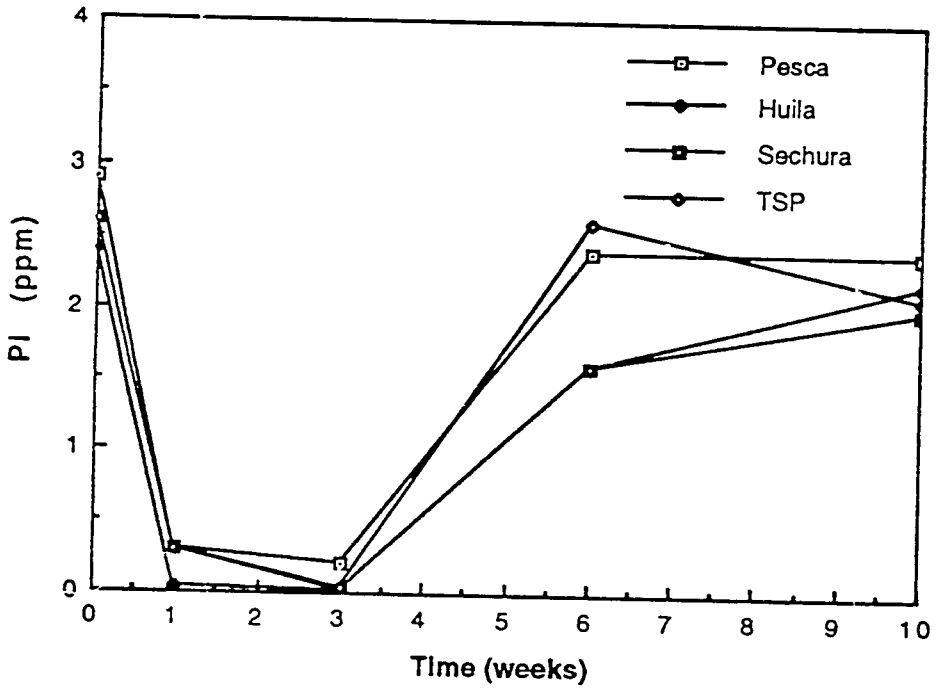

Fig.10 PI changes in a Hartselle soil treated with four different P sources during 10-week incubation study

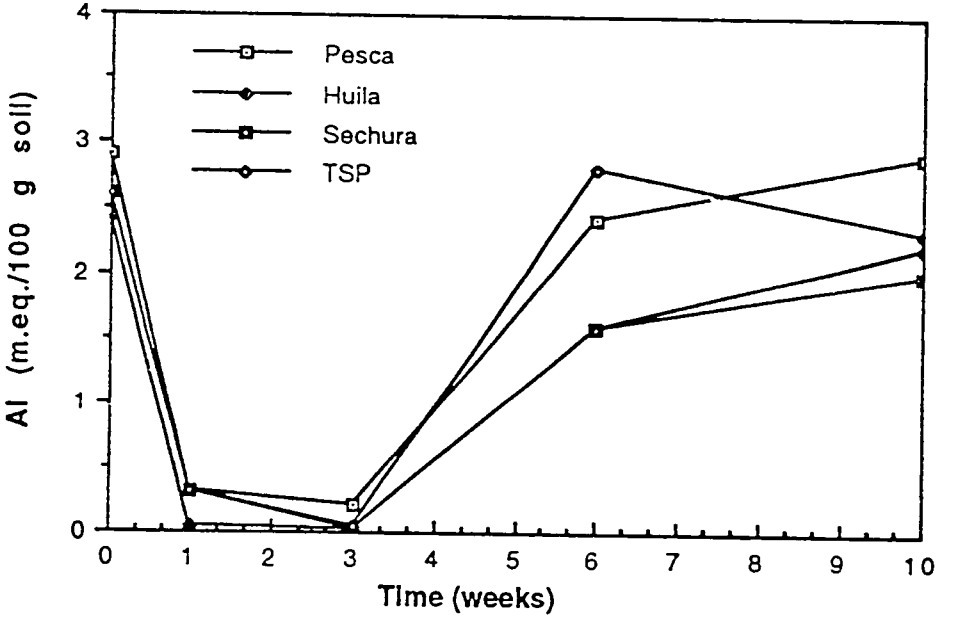

Fig.11 Exchangeable Al in Hartselle soil treated with four different P sources during 10-week incubation study

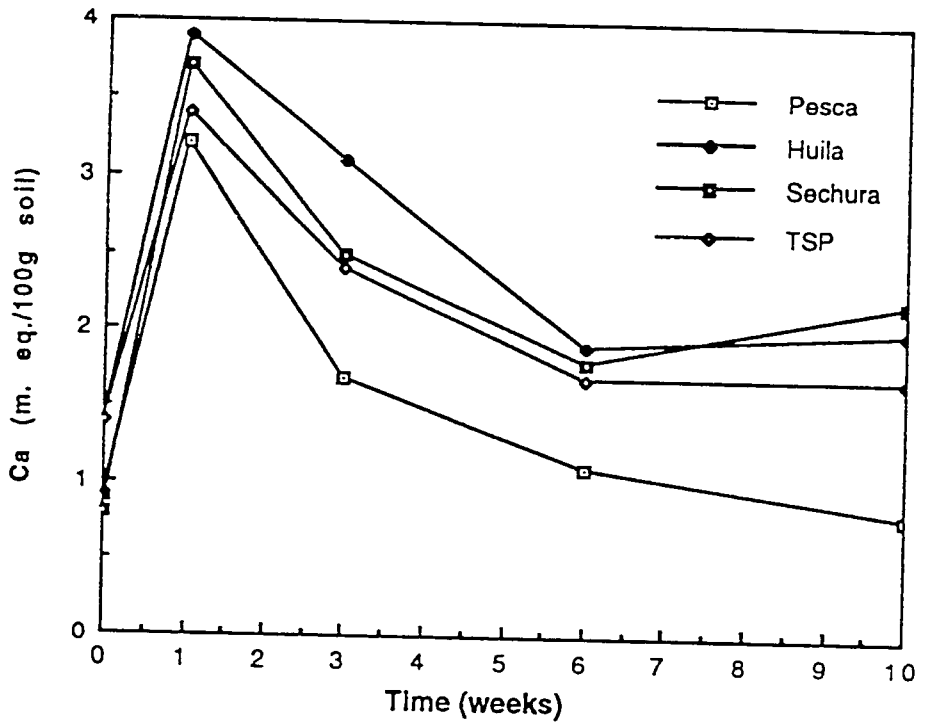

Fig.12 Exchangeable Ca in a Hartselle soil treated with four different P sources during 10-week incubation study

Memorandum

IFDC INTERNATIONAL FERTILIZER DEVELOPMENT CENTER . . . MUSCLE SHOALS, ALABAMA 35660
P.O. BOX 2040 . . . 205-381-6600
TWX-810-731-3970 IFDEC MCHL

To: Central Files

From: Sen H. Chien, Soil Scientist, Resources Management Research and Development Division

Date: August 10, 1992

Subject: TRIP REPORT--BOGOTA AND VILLAVICENCIO, COLOMBIA--JULY 27-31, 1992

The main purpose of this trip was to discuss with researchers at the Colombian Institute of Agriculture (CIA) the field trials as proposed in the USAID-funded IFDC/Alabama A&M University joint project entitled "Use of Indigenous Phosphate Rocks for Aluminum-Tolerant Soybean Cultivars in Humid Tropical Soils." Dr. R. W. Taylor, Associate Professor, Department of Plant and Soil Science, Alabama A&M University, accompanied me on the trip.

We arrived in Bogota July 27 and were greeted by Dr. L. A. Leon, IFDC's Soil Scientist stationed at CIAT, Cali, Colombia. The next day we drove across the Andes Mountains to Villavicencio, a city located between the edge of the Andes Mountains and Colombia's Eastern Plain (Llanos Orientales). The next day we went to visit ICA's La Libibertad Experimental Station where we met with Ing. Luis Fernando Sanchez, Soil Scientist, and our collaborator for conducting field trials. First we went to visit the field trials that Ing. Sanchez is currently working on for a project with Texasgulf Company. North Carolina PR, Huila PR,and Huila-PAPR (25% and 50% acidulation) are being compared with TSP using upland rice as the test crop. In general, all the P sources show good P response, and the differences among P sources are small by observation.

The major discussions and conclusions with respect to the USAID-funded project are as follows:

1. During the first semester, which begins in mid-August 1992, for planting soybean seeds, Huila PR, Pesca PR, and TSP will be compared as P sources for ICA's Al-tolerant soybean cultivar on an Oxisol. The soil will be limed to raise soil pH from 4.5 to 4.8. P rates will be 0, 50, 100, and 150 kg P/ha. On the unlimed soil, only Huila PR and TSP will be used with P rates at 0 and 150 kg P/ha.

2. Because the quantities of seeds of the two United States Al-tolerant soybean cultivars (Forest and Padre) obtained by

Central Files
August 10, 1992

TRIP REPORT--BOGOTA AND VILLAVICENCIO, COLOMBIA--JULY 27-31, 1992

In summary, the trip was very productive. If the results turn out to be very promising, Dr. Taylor and I will prepare and submit a new proposal to USAID for possible extension of this project beginning in October 1993.

S. H. Chien

Sen H. Chien

SHC:nbp
cc: C. A. Baanante
O. W. Livingston
A. U. Mokwunye
K. L. Moots
A. H. Roy
J. J. Schultz

TRIP REPORT

by DR. ROBERT TAYLOR

JULY 27 - 31, 1992

VISIT TO COLOMBIA, SOUTH AMERICA FOR PROJECT ON
"USE OF INDIGENOUS PHOSPHATE ROCKS FOR ALUMINUM TOLERANT SOYBEAN CULTIVARS IN HUMID TROPICAL SOILS"

Contact Persons:

Luis Fernando Sanchez - ICA Agronomist
Dr. Edgar Amezquita - Director of Natural Resource in Colombia

PHOSPHATE ROCKS FOR ALUMINUM TOLERANT SOYBEAN CULTIVARS IN HUMID TROPICAL SOILS

TRIP REPORT

Traveler: Dr. Robert W. Taylor

Country Visited: Colombia, South America

Period of Trip: July 27 to July 31, 1992

Purpose of Trip: To meet with Colombia's ICA cooperator who will be establishing and maintaining the field trial to design the experiment, to observe the field sites and to plan the logistics.

Contact Persons Met During the Visit:

Dr. Alfredo Luis Leon, Soil Chemist IFDC/CIAT
Mr. Carlos Luna, Chemist IFDC/CIAT
Mr. Luis Fernando Sanchez, ICA Agronomist
Dr. Edgar Amezquita, Director of Natural Resources

Executive Summary

Upon the traveller's arrival in Bogota, Colombia and having been met by Dr. Alfredo Luis Leon and Carlos Luna, both of whom work for The International Fertilizer Development Center (IFDC) but are stationed at CIAT in Cali, Colombia, the next day he travelled to Villavicencio; there he met with Mr. Luis Fernando Sanchez the ICA Agronomist who will be establishing and maintaining the soybean/phosphate rock field experiment. They all travelled to visit the experimental sites and later met to design the field experiment and work out the logistics over a two (2) day period. Before returning to the USA the traveller and associates met in Bogota with Dr. Edgar Amezquita, the Director of Natural Resources, Colombia. He was briefed on the experiment and his permission to use ICA personnel to establish and manage the experiment was obtained. The following morning the traveller left Colombia for the USA.

Detailed Trip Report

July 27, 1992

I, Dr. Robert Taylor left Huntsville, Alabama at 7:12 a.m. on American Airlines Flight 1808 to Nashville, TN and took American Airlines Flight 1651 to Miami, Florida where I met Dr. Chien and we both arrived in Bogota, Colombia on American Airlines Flight 915 at 8:39 p.m. (Eastern Time). We were met at the airport by Alfredo Luis Leon and Carlos Luna (who acted as hosts and stayed with us throughout the trip). From that point we proceeded to the Hotel Cosmos 100, Bogota after clearing customs with the soybean seeds and the Bradyrhizobium inoculum. We spent the night in the hotel.

July 28, 1992

We left Bogota at 8:00 a.m. and drove across the mountains for 3 hours to the city of Villavicencio where we checked into the hotel and went for lunch.

After lunch we drove to ICA's (The Institute Colombiano Agropecuario--Colombian equivalent of USDA) La Libertad Experiment Station to visit with Luis Fernando Sanchez, the ICA's Agronomist who will be establishing and maintaining the field experiment. Luis Fernando Sancehz was out in the field in another area so we could not visit with him at that time. However, we stayed at the station and visited the soil testing and soil physics laboratories.

After the laboratory visits we travelled to the nearby CIAT (Centro International de Agriculture Tropical) rice research experiment station.

At 5:30 p.m. we returned to the hotel and ended the working day.

July 29, 1992

After breakfast we met with Luis Fernando Sanchez, the ICA Agronomist, in the hotel. Following our meeting, we traveled with him to San Martin to visit and observe the area where he plans to establish our experiment on phosphate rock effects on the soybean cultivars we brought with us. Adjacent to the area we observed one of Luis Fernando Sanchez's experiments on the effect of phosphate rock on the yield of rice. We collected a soil sample from the area where our experiment will be established to take to the Laboratory at the La Libertad Experiment Station (soil pH was determined to be 4.5). We then visited another experiment on the residual effect of phosphate rock on rice about 15 miles away.

We then visited the ICA sub-station in Granada so Luis could put in an order to get the field preparation for herbicide and

lime initiated. We traveled back to Villavicencio and had lunch there.

After lunch we traveled to La Libertad Experiment Station and spent the rest of the afternoon until 5:00 p.m. planning the experiments that Luis Fernando Sanchez will establish and manage.

We discussed and determined the following:

A. Land area required.
B. Experimental design.
C. Number and location of experimental sites.
D. Date of planting.
E. Cost of experiment and manner in which payment should be made to ICA (Luis Fernando Sanchez).

July 30, 1992

After breakfast we left Villavicencio and drove by car across the mountains for 3 hours to Bogota. Once in Bogota we went to the airport to American Airlines to confirm our reservations to leave Colombia the next day. Having accomplished this task we had lunch.

After lunch we went to the Tibaitata experiment station of ICA in Bogota to meet with Dr. Edgar Amezquita, the Director of Natural Resource in Colombia to inform him in more detail about the experiments planned for September 1992 and March 1993 which Luis Fernando Sanchez will establish and maintain. He granted us permission. We visited with other soil scientists at the Tibaitata experiment station, Bogota, after our lengthy and detailed meeting with Dr. Edgar Amezquita and returned to the hotel at 5:30 p.m. to finish the working day.

July 31, 1992

After breakfast we traveled to the airport to clear security, customs, etc. and boarded the American Airlines Flight which departed Bogota, Colombia at 11:40 a.m. for Miami, Florida, USA. Due to a flight delay in Nashville, TN, I did not arrive in Huntsville, Alabama until 11:15 p.m.

cc: Dr. Norman Chien, IFDC
Dr. Alfredo Leon, CIAT, Colombia
Dr. Edgar Amezquita, Director of Natural Resources, Colombia
Mr. Luis Fernando Sanchez, ICA Colombia