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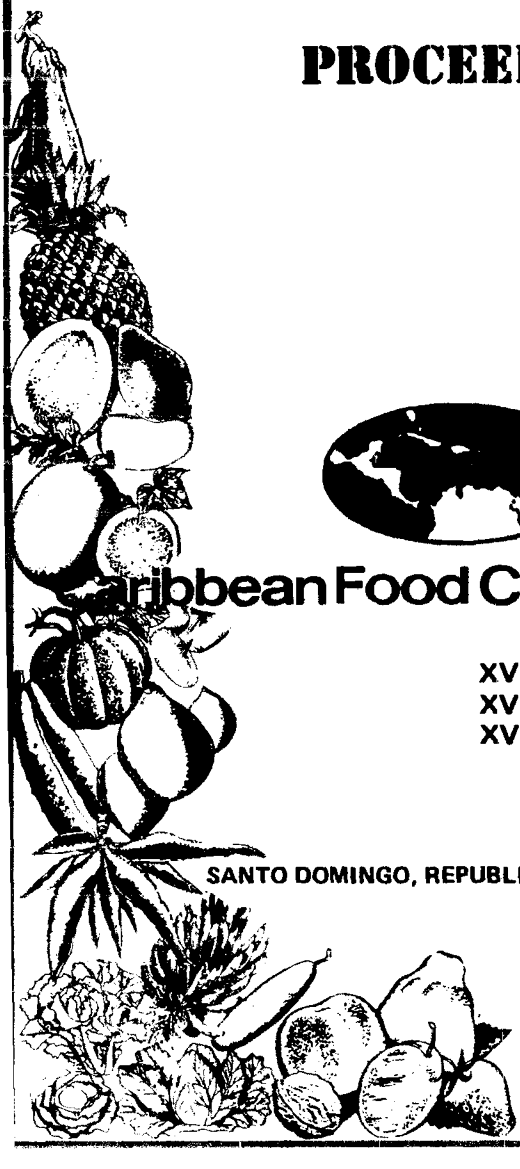

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EXPLORATORY TESTS ON MINERALIZATION OF ORGANIC PHOSPHORUS IN AN ULTISOL

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INTRODUCTION

Recent field experiments on several highly weathered soils of Puerto Rico have failed to elicit a consistent response to fertilizer P applications (7). These results are not in accord with greenhouse trials in which estimates of plant available P indicatea that a definite response to applied P should have occurred (14). Brams (3) reported a lack of fertilizer P in river terrace soils of the West African humid uplands over a continuous 3 year period with corn, rice and groundnuts. He measured a 31 to 87 % increase in labile soil P (Bray No, 2 extract) in the plow layer of the check and treated plots 1 year after fertilizer P was applied. This trend persisted through the third crop year although in diminishing magnitude.

Various equally tenable explanations have been advanced for the lack of response to fertilizer P applications. Figarella et al. (5) suggested the presence of inorganic P that may become available to the plant over the growing season but is not extracted by routine tests. Other workers propose that added fertilizer P becomes fixed or immobilized as insoluble Al, Fe or Ca phosphates (3,6,7,10,11,14). Another possible explanation is that P present in organic form in the solil at the beginn inf og a season may, through mineralization, contribute substantially to the P nutrition, contribute substantially to the P nutrition of plants grown during that season (1,3,4,9,12).

The latter explanation is of particular relevance to soils in Puerto Rico that failed to show a yield response to heavy applications of fertilizer P in the summer but not in the winter months (7). Indeed, the sumer climatic conditions of temperature and rainfall at the experimental site were more conducive to organic P miniralization than were winter conditions (1,12). Also, organic P mineralization could be an important sopurce of plant available P when the high soil organic matter content of 4.25% (7)

is considered.

To recommend the efficient and economic use of fertilizer P in the humid tropics, it is imperative that information be obtained on the contribution of organic P mineralization to the pool of plant available P in these soils. This paper reports data on organic P mineralization' Field and greenhouse studies were conducted to ascertain the effects of temperature and added fertilizer P on this biological process.

MATERIAL AND METHODS

Field Experiment

Field studies were conducted at Cidra, Puerto Rico, using the same site on which the P studies commenced in November 23 and 26, 1971 4/. The soil is classified as Torres clay, an Orthoxic Palehumult. Corn was used as the indicator plant. Attention was focused on plots that received 0, 90, 179, 358 and 1,120 kg/ha of broadcast P. Studies began at the same time when the 1973-74 winter crop was sown.

Beginning on the date of planting and, at 28-day intervals thereafter, through physiological maturity, soil samples were taken at dephths of 0-15, 15-30, and 30-45 cm. Samples were analyzed for organic matter content, organic P, inorganic P, available P by the Olsen and Bray No.2 methods, 5/, total soil N, and pH.

Additionally, plant tissues were sampledat 28-day intervals beginning 30 days after planting and continuing through physiological maturity. Samples were analyzed for P and N.

Plant heights were measured at fixed intervals throughout the growing period and total P and N uptake of grain and stover were determined following harvest. Respiratory activity was measured according to the method outlined in Black et al. 6/

Data on soil and air temperatures, rainfall, evaporation from a class A pan, relative humidity and total radiation were recorded.

Greenhouse Experiments

First Experiment: Torres clay, with a low available P content, (0-2 p/m Olsen and Bray extracts), was brought to the laboratory and prepared 7/. The soil received a blanket application of fertilizer as follows: 300 p/m N as ammonium nitrate, 200 p/m K as muriate, 50 p/m Mg as sulfate, 5 p/m Zn as sulfate, 5 p/m Fe as iron chelate, 0.5 pm Cu as sulfate, and 2.4 p/m B as borax. Enough $Ca(OH)_2$ was added to neutralize the soil exchangeable Al.

4/ Del Valle, R., Personal commnunication, November, 1972.

5/ In recent studies on 155 West Indian soils Olsen's method gave the best estimates of available P (13).

6/ Black, C.A. et al. Methods of soil analysis, Part 2, Amer. Soc. Agron., Madison, Wisc., 1965.

7/ Preliminarry studies on plant available P content of seven samples taken from areas peripheral to the experimental site, and using three methods of determination gave an average value of 2.0 p/m labile P.

Two levels of P were studied: No. P (the check treatment) and 500 p/m of fertilizer P as double superphosphate. These treatments will be hereafter referred to as O P and + P, respetively.

The soils were moistened to near field capacity and allowed to incubate at room temperature for 14 days. They weew kept at field capacity throughout the experiment.

Following incubation, the soils were potted in 20 x 20 cm plastic pots and the pots were taken to a greeenhouse and immersed in water baths adjusted to 20°, 27°, and 35° C. After the soiles were in equilibrium with the water bath temperatures, Funk's G–795W corn was planted in one set of pots having O P and + P. Another set of pots having P and + P were maintained at field capacity but in fallow. Pots were sampled at time of planting and, thereafter, at 15-day intervals through 30 days. Samples were analyzed for the same set of parameters as previously outlined for the field experiments.

Plant heights were measured at weekly intervals beginning 14 days after planting and continuing through 30 days. At this time, plants were harvested and the dry matter data recorded. Plant tissues were analyzed following harvest for total N and total P uptake.

Second Experiment: Corn was planted on the same potted soils as in Experiment 1. Three new sets of pots were added with a –N treatment. There were all possible combinations of P and N treatments at 17, 25 and 35° C. A new blanket fertilizer application was made, as follows: 300p/m N, 250 p/m P in pots where this nutrient was excluded in experiment 1, and 50 p/m Mg. The –N pots received the same blanket application as in Experiment 1.

Third Experiment: New soil was brougt from the field and potted. Three additional sets of pots were included. Then, half of all potted soils were sterilized with methyl bromide for 48 hours. The same blanket fertilizer application as in experiment 1 was made, except that no lime was added.

RESULTS AND DISCUSSION

Data from the field experiment failed to reveal significant differences in respiration rates and soil pH, attributable to previous soil treatments. Soil P levels were higher in plots that previously received 1120 kg/ha of P, with and without lime, than in plots receiving fertilizer P at rates of of 0,90, 179 and 358 kg/ha, with or without lime.

Data from the greenhouse experiments are summarized in tables 1,2 and 3. In all three experiments, yields of corn tops were higher with higher soil temperature when no fertilizer P was added. Values for r ranged fron 0.74 to 0.98. In none of the experiments, was the yield of corn tops correlated with soil temperature when P was added (r = 0.34 to 0.54). Plant P concentration was highly correlated with soil temperature in all three experiments when correlated with soil temperature in two of three experiments when P was added (r = 0.41 to 0.77). Plant O uptake was also correlated with temperature when no P was added (r = 0.82 to 0.98). Plant P uptake was correlated with soil temperature in two of the three experiments when P was added (r = 0.40 to

0.78). All of the above are linear correlations.

With soil sterilization these correlations with soil temperature were not apparent. Sterilizing the soil significantly increased N concentration and decreased K concentration at all three temperatures. There was biological activity (CO_2 evolution) in both sterilized and non-sterilized soils by the end of the growing period. Increases in P. uptake of corn tops with increases in soil temperature from 17 to 35° C., with no added P, were of the order of over 300 %.

It appears as though the failure to obtain responses to fertilizer P applications on Ultisols can be explained on the basis of the mineralization of organic P that occurs at the prevailing higher soil temperatures. Mean soil temperature at 15 cm under field conditions, as measured during the course of these experiments, was 24.2°C. from January 1 to March 15. An average maximun soil temperature of 28.3°C was measured. In the summer months, mean soil temperature in the field at 15 cm was 28.0°C. This situation might explain, to some extent, the lack of response to fertilizer P usually observed in Ultisols and other highly weathered soils of the humid tropics.

Weaver [8] observed that wetting and drying of soil samples at 35° C appeared to be the most effective treatment causing mineralization of organic P under laboratory conditions. His work with the Catalina, Humatas and Torres soils confirm results in the literature that added lime and increased temperature cause an increase in mineralization of organic P (7). The greatest amount of mineralized P was obtained from Torres clay. Most of the organic P mineralized appeared to be that extracted by either 0.3 **N** NaOH or HCl = NaOH.

8/ Weaver. R. M., Personal comunication, February 19, 1974.

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RESUMEN

Se realizó un experimento de campo para medir el posible efecto residual de aplicaciones previas de P y tres experimentos diferentes, en invernadero, para determinar la relacion entre la absorción de P y los niveles de P orgánico en el suelo, P inorgánico y P disponible a las plantas. También se estudió el efecto de la temperatura del suelo, las aplicaciones de P y N y la esterilización del suelo sobre la mineralización del P orgánico. Los datos obtenidos en el campo no revelaron diferencias significativas en la respiración de la planta y en el pH del suelo. Los niveles de P fueron más elevados en parcelas que habían recibido 1120 kg/ha de P, con o sin cal, que en las que recibieron cantidades menores. En los experimentos de invernadero se encontró: 1) Alta correlación entre los rendimientos de la parte epigea de las plantas de maíz y la temperatura del suelo, cuando no se abonó con P. 2) Alta correlación entre la concentración y la absorción de P en la planta con la temperatura del suelo cuando no se aplicó P como abono. 3) La esterilización del suelo con bromuro de metilo aumentó significativamente el nivel de N y disminuyó el de K en la planta, independientemente de la temperatura del suelo. Se postula que la mineralización del P orgánico en los Ultisols, y quizás en otros suelos tropicales altamente intemperizados, puede explicar, por lo menos en parte, la falta de respuesta a las aplicaciones de abonos fosfatados que generalmente se observa.

TABLE 1.
Yield, plant nutrient concentration and nutrients uptake of corn grown in pots under greenhouse conditions at two P levels and two soil temperatures.

Treat-ment No.	P added	Soil tempera-ture	Yield Top	Root	Plant nutrient concentration N	P	K	Nutrient uptake of tops N	P	K
		P/m	oC·	G/pot	——	——	o/o	——	——mg/pot——	
1	0	35	7.75b–1	4.51a	4.25c	.22b	6.73b	329c	17.2c	522c
2	500	35	17.47d	6.87b	4.20bc	41cd	5.78a	734e	54.8e	1010d
3	0	25	5.29a	3.58a	3.96b	.81a	7.95b	209b	9.5b	374b
4	500	25	16.26cd	3.91a	4.61d	.33d	6.68b	749e	53.6e	1083d
5	0	17	3.29a	3.69a	3.69a	.14a	7.20b	122a	4.6a	236a
6	500	17	14.90c	6.48b	4.04bc	.27c	6.73b	600d	39.6d	994d

1/ Means followed by the same letters do not differ significantly at the 5% level of probability.

Table 2. Yield, plant to nutrient concentration and top nutrient uptake of corn tops grown in post under greenhouse conditions at two P levels, two N levels and three soil temperatures.

Treat-ment No.	P added	N added	Soil tempera-ture	Yield of cor tops	Plan top nutrient concentration			Nutrient uptake of tops		
					N	P	K	N	P	K
	P/m		oC	G/pot	–––	o/o	–––	–––Mg/pot		–––
1	250	0	35	13.35b--1	2.86b	.44f	6.93d	377e	58.1de	921d
2	250	0	25	13.43b	2.18a	.37e	6.86cd	291de	49.3cd	923d
3	250	0	18	11.85b	2.30a	.31cd	6.30bc	273cd	36.4b	747bc
4		300	35	4.65a	4.00c	.16b	5.85b	185bc	7.4a	273a
5	250	300	35	20.83c	3.79c	.31d	4.55a	788g	67.6e	956d
6	0	300	25	2.94a	3.95c	.12a	6.30bc	116ab	3.4a	186a
7	250	300	25	20.06c	3.91c	.31cd	4.59a	780g	62.2e	908cd
8	0	300	18	1.95a	4.42d	.12a	6.00b	86a	2.3a	117a
9	250	300	18	16.60c	3.95c	.28c	4.08a	656f	46.3bc	676b

1/ Means followed by the same letters do not differ significantly at the 5% level of probability

Table 3. Yield, plant top nutrient concentration and top nutrient uptake of corn tops growing in pots under greenhouse conditions at two P lvels in sterilized and non-sterilized soils

Treat-ment No.	P added	Soil sterilization	Soil tempera-ture	Yeld of corn tops	Plant top nutrient concentration N	P	K	Nutrient uptake of tops* N	P	K
1	o	Sterilized	35	2.03a	6.45ef	.14a	4.34a	132a	2.85a	87a
2	0	Non-sterilized	35	3.78a	4.22ab	.24b	8.21d	161a	9.38a	312c
3	500	Sterilized	35	13.65d	5.16d	.36d	6.62bc	705bc	49.68c	907d
4	500	Non-sterilized	35	10.60b	4.13ab	.38d	8.13d	436b	40.90b	861d
5	0	Sterilized	27	2.07a	6.88f	.12a	4.03a	143a	2.55a	84a
6	0	Non-sterilized	27	3.22a	4.02ab	.22b	8.16d	130a	7.20a	265bc
7	500	Sterilized	27	17.10e	5.11d	.39d	6.91bc	870d	67.07d	1177e
8	500	Non-sterilized	27	11.25bc	4.48bc	.38d	8.02d	503b	42.22bc	901d
9	0	Sterilized	18	2.10a	6.00e	.13a	4.57a	126a	2.70a	96a
10	0	Non-sterilized	18	2.28a	3.83a	.13a	6.47bc	88a	2.97a	147ab
11	500	Sterilized	18	13.08cb	4.80cd	.31c	6.34b	626c	40.55b	848d
12	500	Non-sterilized	18	11.75bcd	4.14ab	.30c	7.21c	486b	34.63b	848d

1/ Means followed by the same letters do not differ significantly at the 5% level of probability