SHORT COMMUNICATION

PHOSPHORUS FIXATION IN OXISOL OF CENTRAL BRAZIL

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SUMMARY

Phosphorus fixation capacity is one of the most important growth limiting factors in crop production in oxisols of Central Brazil. In order to monitor changes in applied P after fertilization, dark red latosol, suborder ustox, was incubated up to 80 days with 0, 25, 50, 75, 100, 150, 175 and 200 mg P/kg of soil. Phosphorus was periodically extracted with Mehlich 1 extracting solution. Extractable P values declined rapidly up to 17 days of reaction time and then become more or less constant. The data presented describe the extent of P fixation with respect to the amount of P added and reaction time. Phosphorus fixation was 77 to 90% depending on levels of P applied. These results suggest that this type of soil needs large amounts of P for optimum crop production.

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Oxisols and ultisols are predominant in the tropical regions of the world which are highly acid and low in nutrients, especially phosphorus. Several soil properties, especially clay and Fe and Al contents, are closely related to the P sorption capacity of these soils. Due to low natural phosphorus and high fixation capacity, a heavy dose of P is needed to achieve high production on these soils (Fageria et al., 1982, Yost et al., 1979). Phosphorus deficiency on high P-sorbing soils can be corrected by an initial application of a large quantity of P, repeated band applications of P, or a combination of an initial broadcast application and repeated band applications (Yost et al., 1979).

A knowledge of the quantity of P fixed in oxisols is very important to improve the soil analysis interpretation and fertilizer recommendations to increase crop yields. Several studies about P fixation in oxisols have been reported in the literature (Bahio Filho et al., 1983, Fox & Kamprath, 1970, Yost et al., 1981). But all these studies were conducted with a few hours of incubation time and under laboratory conditions. Very limited information is available for long incubation time in the greenhouse with natural soil conditions.

Because of the importance of oxisols for crop production in various parts of the world, the objective of this investigation was to evaluate the P fixation capacity of oxisols under greenhouse conditions. Results obtained in this investigation will generate information on P fixation and its availability in oxisol of Central Brazil.

MATERIALS AND METHODS

The greenhouse experiment was conducted at the National Rice and Bean Researh Center - CNPAF - in Gioânia, Gioas (Brazil). The test soil was a dark red latosol (Typic Eutrustox), having an initial pH of 4.3, extractable P 1.1, Ca + Mg 0.9, K 42, and Al 0.09 mg/kg. Phosphorus and K were extracted by the Mehlich I extracting solution (0.055 mol/l HCl + 0.0125 mol/l H_2SO_4). Phosphorus was determined by colorimetry and K by flame photometry. Ca and Mg were determined by titration with EDTA and Al by titration with NaOH.

Phosphorus levels added as triple superphosphate were 0, 25, 50, 75, 100, 125, 150, 175 and 200 mg/kg P in plastic pots containing 6 kg of soil. The treatments were replicated 4 times in a randomized complete block design. Basal application of fertilizers in each pot was 400 mg N through ammonium sulfate, 960 mg K through potassium chloride, 1000 mg FTE-BR-12 source of micronutrients and 15 g dolomitic limestone. The objective of applying basal fertilizer was that the oxisols of Central Brazil are very low in nutrients and need fertilization for conducting a greenhouse experiment. The availability of P changed with basal fertilizer application, especially liming. Soil samples were taken from each treatment at 0, 17, 31, 45, 60 and 80 days after application of P treatments.

All pots were watered to maintain soil moisture at approximately field capacity during the experimentation. An analysis of the data variance was made and regression analysis was used for estimating P fixation in relation to P applied and time of reaction.

RESULTS AND DISCUSSION

The relationship between P applied and extractable P at two reaction times is shown in the figure. Extractable P was increased with increasing levels of P. Increase was slow at lower levels of P and increased sharply at higher levels of P application. There was practically no difference in extractable P up to 100 mg/kg of applied P at 0 and 80 days reaction times. At higher levels of P, extractable P was decreased at 80 days reaction time in comparison with 0 reaction time. This means that there was more P fixation at higher P levels. At 200 mg P levels and 80 days reaction time, the value of extractable P was 43 mg, whereas it was about 55 mg P at 0 reaction time at the same P level. This decline in extractable P with time would be expected, given the usual pattern of decrease of solution P while in contact with an absorbing surface and conversion of soil P to less soluble forms (Yost et al., 1981). Adsorption mechanisms prevail at low P concentrations (Lin et al., 1983). Reactions of P with soil may involve both adsorption and precipitation which are thought to result from the same chemical force (Lin et al., 1983). Regression equations, coefficients of determination (R^2) and standard errors of estimate (SE) for the relationship between P extracted and P applied at different reaction times are presented in Table 1.

Percent recovery of P as a function of applied P and reaction time is presented in Table 2. There was a decrease in P recovery up to 17 days of reaction time. Thereafter, P recovery was constant. Ibrahim & Pratt (1982) and Yost et al. (1981) also reported decrease in labile P with time. It is also reported by Van Riemsdijk & De Haan (1981) that the reaction of phosphate (P) with soils which are initially free of sorbed P, and with metal oxides/hydroxides, is a very fast reaction at the beginning, slowing down substantially during the course of reaction. In the present study, soil was taken from virgin area and highly weathered acid soil having high Al and Fe oxides/hydroxides (Lopes & Cox, 1977). For soils not free of sorbed P, top layers of arable soils for instance, the initial reaction is not very fast (Van Riemsdijk & Van der Linden, 1984).

Phosphorus recovery increased with increasing levels of P. Average values showed that at 25 mg P levels there was only 10% recovery of applied P, whereas, at highest level of applied P, the recovery was 23%. This means P fixation was 77 to 90% depending on the level of P applied. These results suggest that dark red latosols of Central Brazil have a high P fixation capacity. This capacity is related to low pH and high iron oxide contents, Al saturation and clay fractions that are composed primarily of kaolinite, gibbsite and iron oxides (Smyth & Sanchez, 1982).

To obtain high production in these soils, it is necessary to apply very high P rates in the beginning of the cultivation.

CONCLUSION

The purpose of the experiment was to evaluate phosphorus behavior in acid soils as a function of applied P and reaction time. Results clearly showed that soil under study had a higher P retention capacity which varied from 77 to 90% depending on the level of P application. Phosphorus fixation was high at the beginning and decreased with time of reaction. It means soluble P should not be applied to this type of soil too far in advance of planting to avoid P deficiency at the beginning of crop growth, especially in the first year of cultivation.

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TABLE 1

Regression equations, R^2 and SE values for the relationship between P extracted (Y) and P applied (X) and influenced by time reaction

Time reaction (days)	Equation	R^2	SE
0	$Y = 2.7716 + 0.0224x + 0.0012x^2$	0.98	0.0002
17	$Y = 0.1981 + 0.1556x + 0.0002x^2$	0.98	0.0001
31	$Y = 1.0713 + 0.2072x - 0.0001x^2$	0.98	0.0001
45	$Y = 0.1548 + 0.1567x + 0.0003x^2$	0.97	0.0002
60	$Y = 1.6328 + 0.0547x + 0.0008x^2$	0.98	0.0002
80	$Y = 1.3192 + 0.0989x + 0.0005x^2$	0.97	0.0002

SE = standard errors of estimate for the quadratic equation.

TABLE 2

Percentage recovery of P as a function of P concentration and reaction time

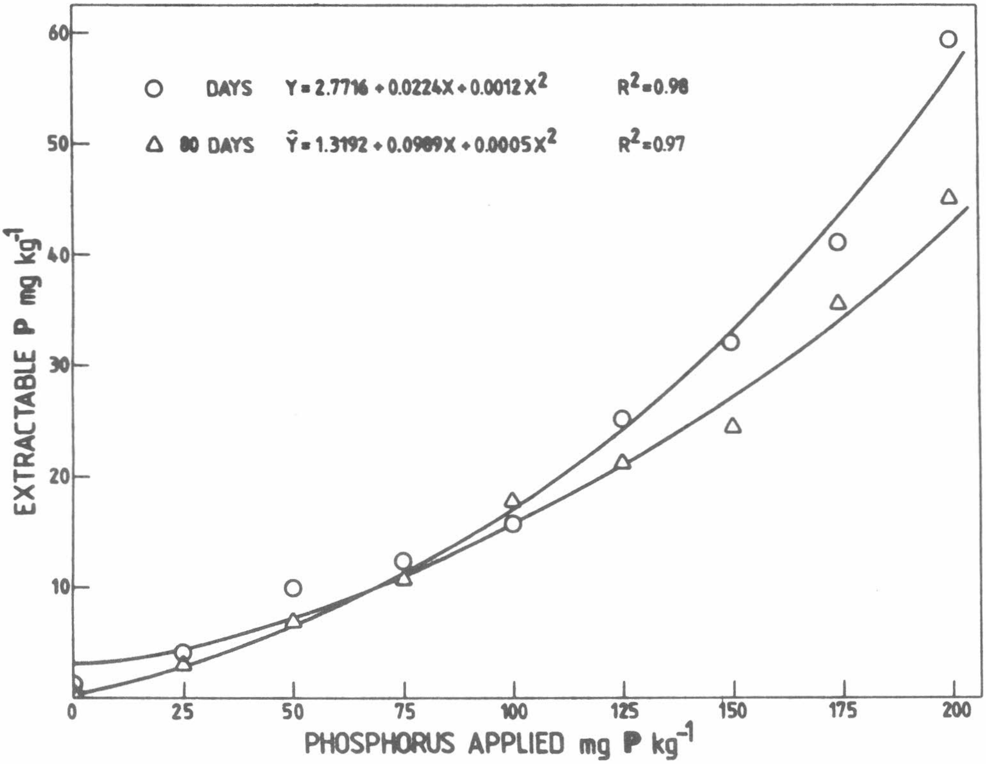
P applied mg/kg	Reaction time (days)						Average
	0	17	31	45	60	80	
0	-	-	-	-	-	-	-
25	13	7	7	6	12	13	10
50	17	16	10	16	12	13	14
75	16	16	19	14	13	14	15
100	15	17	22	21	13	20	18
125	20	17	20	18	17	18	18
150	21	22	18	19	21	15	19
175	23	20	20	19	19	17	20
200	29	20	19	23	24	23	23
L.S.D. (0.05)	5.82	4.38	5.43	4.32	5.39	4.73	
Average	19	17	17	17	16	17	

TABLE 3

Regression equations, R^2 and SE values for the relationship between percent P recovery (Y) and time reaction (X) as influenced by P levels

P levels mg/kg	Equation	R^2	SE
25	$Y = 11.5882 - 0.2699x + 0.0037x^2$	0.76	0.0012
50	$Y = 16.5769 - 0.1191x + 0.0009x^2$	0.32	0.0017
75	$Y = 15.9591 + 0.0166x + 0.0007x^2$	0.35	0.0013
100	$Y = 15.7856 + 0.1449x - 0.0013x^2$	0.30	0.0018
125	$Y = 19.1571 - 0.0388x + 0.0002x^2$	0.19	0.0009
150	$Y = 20.5826 + 0.0286x - 0.0010x^2$	0.51	0.0014
175	$Y = 22.3822 - 0.1142x + 0.0009x^2$	0.94	0.0002
200	$Y = 26.9814 - 0.2865x + 0.0032x^2$	0.45	0.0022

SE = standard errors of estimate for the quadratic equation.



Relationship between P concentration and P added
at two reaction times