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Phosphorus Soil Test Change Following the Addition of Phosphorus Fertilizer to 16 Kentucky Soils

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Introduction

When applying phosphorus to soils it is important to know how much the soil test P changes with the addition of various rates. Soils are different in how they respond to varying rates of application, and only limited information is available for Kentucky soils.

Methods

Sixteen soils representing western and central Kentucky were identified as major soils for agronomic crops. A large amount of A horizon was collected with a shovel and placed into a clean, plastic 5-gallon pail, and covered. Later the soil was spread onto brown paper covered benches, air dried, ground and placed into plastic canisters. Table 1 lists the soil series, mapping unit designation and county from which each soil was obtained.

Laboratory grade ammonium dihydrogen phosphate was dissolved into deionized water to make a stock solution. From this stock solution various volumes were added to 50 grams dry soil resulting in seven rates of P_2O_5 (0, 38, 76, 114, 152, 190 and 228 lbs/ acre). The check treatments had only deionized water added and each treatment was duplicated. The treated soil was placed in a 4-ounce plastic container, mixed thoroughly, moistened to field capacity, then uncapped, and the open containers set on shelves in a closed cabinet. After 4 wk the containers were capped, mixed, re-moistened to field capacity, uncapped and set back on the shelves for an additional 4 wk. At the end of the second 4 wk period (8 weeks total), the samples were sent to the UK Soil Testing Lab to be analyzed for P following extraction with Mehlich III solution.

Table 1. Soil series, mapping unit and county from which soil was obtained.

Soil series	Mapping unit	County
Allegheny	Al	Jackson
Baxter	BaB	Warren
Belknap	Bk	Webster
Falaya	Fa	Marshall
Grenada	GrA	Marshall
Lonewood	Lo	Russell
Lowell	LwB	Nelson
Maury	MlB	Fayette
Melvin	Me	McLean
Newark	Ne	Ohio
Pembroke	PeA	Warren
Pope	Po	Breathitt
Sadler	SaB	Ohio
Shelbyville	ShB	Nelson
Trappist	TpC	Nelson
Zanesville	ZaB	Caldwell

Results

Table 2 lists the soil test P for the 16 soils following the addition of seven phosphorus rates and an 8-wk incubation as extracted by the UK Soil Testing Lab.

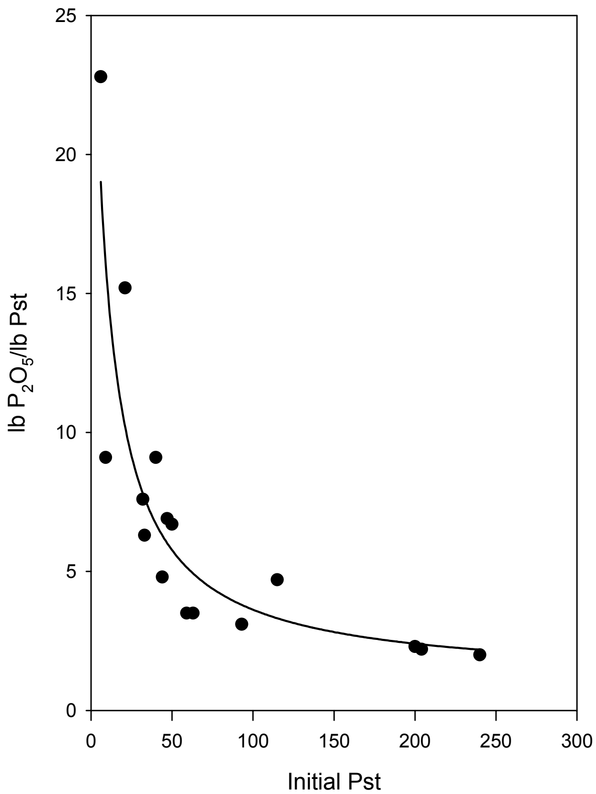
Soils with lower initial soil test P values had lesser increases in soil test P than soils with higher initial soil test P values. For example, the Lonewood (Lo) soil increased soil test P by 115 lbs/acre with 228 lbs of added P_2O_5/acre, the Newark (Ne) soil increased soil test P 48 lbs/acre, and the Baxter (BaB) soil increased soil test P only 10 lbs/acre. The Lo soil had the highest initial soil test P level, the Ne was intermediate, and the BaB was lowest of the 16 soils. Figure 1 plots the calculated P_2O_5 amount that changed soil test P by 1 lb/acre for each of the 16 soils using data after incubation. The soil test P value of the check treatment (0 lbs P_2O_5/acre) was subtracted from the soil test P value measured following 228 lbs P_2O_5/acre addition. This difference was then divided into 228 (or 228 / difference).

Table 2. Soil test P as affected by rates of P addition and following an 8-wk lab incubation.

Soil series	Lbs P_2O_5/acre added: 0	38	76	114	152	190	228
	- - - - - - - Soil test P (lbs/acre) - - - - - - - -						
Al	93	104	110	126	144	158	167
BaB	6	6	8	8	10	14	16
Bk	33	39	42	50	60	63	69
Fa	50	54	56	70	69	80	84
GrA	204	235	255	265	285	310	310
Lo	240	265	285	295	320	330	355
LwB	32	34	37	43	46	57	62
MlB	115	121	131	135	145	152	164
Me	59	68	77	88	103	107	125
Ne	44	49	56	66	78	81	92
PeA	200	205	255	260	265	280	300
Po	21	26	28	28	31	34	36
SaB	47	49	54	59	63	67	80
ShB	40	47	49	50	57	59	65
TpC	63	84	95	104	104	106	129
ZaB	9	11	14	18	22	27	34

This data indicated that when soil test P started at 200+ lb/acre, the soil test P increase was near the maximum rate of change where each 2.29 lbs P_2O_5 would increase soil test P by 1 lb/acre. When initial soil test P ranged from 50 to 115 lbs/acre soil test P increased 1 lb with each 3 to 5 lbs added P_2O_5/acre, and initial soil test P within a range of 25 to 50 lbs/acre needed from 5 to 9 lbs P_2O_5/1 lb Pst. As initial soil test P fell below 25 lbs/acre, there were large and variable (depending on soil) amounts of P_2O_5 needed to increase soil test P by l lb/acre.

Figure 1. The amount of added P2O5/acre that



changed soil test P 1 lb/acre following an 8-wk incubation.

Discussion

Soils with an initially low soil test P value required more P_2O_5 to change soil test P and had the greatest variability in the amount of phosphate needed to change soil test P. This variability could be associated with the each soils's differing ability to adsorb phosphorus. Adsorbed phosphorus would reduce the amount being extracted by the Mehlich III solution for agronomic recommendations.

This study used inorganic phosphorus during the incubation that is closely related to commercial fertilizer sources. With the recent concerns about animal manure containing significant organic P, further studies are needed to determine how this form reacts to change soil test P. Generally, as animal manure is decomposed in the soil, the P would be released to react with the soil except for reaction delays with decomposition. Most animal manure does contain some inorganic P (ranging from 10 to 30 %) depending on the species and the amount of dicalcium phosphate used in the ration. At this time it is unknown how much organic phosphorus would be extracted by the Mehlich III extractant.

When soil test P levels are below the agronomic critical level of 60 for most crops (80 for tobacco) more phosphate is required to change soil test P which may decrease the economic returns for added phosphate. On the other hand, when soil test P reaches a level of 100 lbs +/acre, considerably less additional phosphate (per unit of soil test) is needed to increase soil test P.

Livestock producers using animal manure at rates based on crop nitrogen needs may find that soil test P changes quite rapidly. Developing alternative cropping or animal manure application strategies resulting from a high priority on phosphorus management will be important. At a soil test P of 200 lbs +/acre, the soil test P may increase l lb/acre for each l lb/acre of actual P added (1 lb P = 2.29 lbs P2O5) in a crop nutrient source.

This study did not determine any long-term affects on soil test change. The 8-wk incubation period was more closely related to what happens during one growing season without plant growth. Removal of P did not occur in the lab but would occur in the field with a growing crop. Also, as part of the soil chemical reactions, there would be some compounds formed that are more difficult to extract. This would reduce the soil test P even though phosphorus had been added to the soil.

Summary

1. Results of a P incubation study with 16 soils indicated that soil test P changed with varying amounts of P_2O_5 based on the initial soil test P as outlined in Table 3.

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Table 3. Amounts of P_2O_5 needed to increase or decrease soil test P 1 lb/acre at various ranges of initial soil test P.

Initial soil test P range	Amounts P_2O_5/ 1 lb soil test P
200 + lbs	2.3
125 - 200 lbs	3.0 - 2.3
60 - 125 lbs	5.0 - 3.0
30 - 60 lbs	8.0 - 5.0
< 30 lbs	25.0 - 8.0

2. Lower initial soil test P values required more P_2O_5 to change soil test than did higher initial values.

3. Changes in soil test P with phosphate addition at initial values above 200 lbs P/acre can be rapid.

4. This data indicates soil response when phosphorus is added in excess of that removed by a harvested crop from a soil or field. It is likely that soil test P would decrease at similar rates when removed phosphorus is in excess of applied phosphorus.

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