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EFFECTS OF PHOSPHORUS, COWPEA RESIDUES AND LIME ON SOIL PROPERTIES, GROWTH AND MINERALS CONTENT OF MAIZE (*ZEA MAYS L.*) IN YASOTHON SOIL

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ABSTRACT : The glasshouse pot experiment was carried out at KhonKaen University during March 1989. Yasothon soil (Oxic Paleustults) was used to investigate the effects due to the application of Phosphorus (0 , 58, 116, and 174 kg P_2O_5 /ha), cowpea residues (0, 6.25 and 12.50 ton/ha), and lime (0, 625 and 1,250 kg/ha). A factorial design arranged in randomized complete block with three replications was used. The results showed that P application greatly increased maize shoot dry matter yields and cowpea residues ranked the second but lime did not. Cowpea residues increased available soil P and soil organic matter whilst P sinificantly increased soil P but lime did not. P decreased the percentages of N, K and Ca but increased the percentages of P in the plant shoots. Cowpea residues significantly increased the percentages of N and K in shoots. The application of P significantly increased total uptake of N, P, K and Ca in shoots of maize plants.

INTRODUCTION

There has been a number of pot experiments concerning phosphorus proven useful in understanding soil and plant relationships e.g. Prabhakaran Nair and Mengel (1984), Rhue and Everett (1987) and Barry and Miller (1989). The experiments on the importance of agricultural waste products in improving the production of crop yields have also been advocated such as Hoyt and Turner (1975), Ketcheson and Beauchamp (1978) and Ahmad and Tan (1986). Furthermore, the work on problem soils particularly soil P have also been emphasized e.g. Mengel and Kirkby (1987) and Sanchez and Uehara (1980). The latter workers have emphasized how the poor soils in the tropic can contribute in producing crop yields. Moreover Mengel and Kirkby (1987) stated that crops with a high growth rate, producing large quantities of organic materials, have a high demand for P particularly maize. Therefore it is neccessary to carry out the work concerning how the maize plant responses to the different levels of P added to the poor soil together with the improvement of soil by the use of crop residues and lime.

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MATERIALS AND METHODS

The pot experiment was carried out under the glasshouse at Khon Kaen University during March 1989. The soil used was Yasothon soil (Oxic Paleustults) at the amount of 4 kilogrammes airdried soil per pot. The soil chemical properties analysed were: soil pH (5.50) organic matter percentages (0.76), total N (0.03%), available p (4. 41 ppm), and exchangeable K (11.57 ppm). The soil moisture content was maintained at approximately field capacity level by daily watering to weight with deionized water, the design used was a factorial arranged in randomized complete block with three replications. The treatments consisted of four levels of phosphorus. They were : 0, 58, 116 and 174 kg $P_2 O_5$ /ha in the form of $Ca (H_3 PO_4)_2 .H_2 O$. Cowpea residues were ground into meshes and were added to the soil at the rates of 0, 6.25 and 12.50 ton/ha.The lime was also added at the rates of 0, 625and 1,250kg/ha inthe form of $CaCO_3$. These made up a total of 36 treatments. The soil in each pot was added with urea (46% N) at the rate of 46 kg N/ha and KCL at the rate of 48 kg $K_2 O$/ha for fertilizer basement. The materials used were thoroughly mixed accordingly into the soil and daily watering to field capacity for one week before sowing. 5-6 maize (*Zea mays* L.) seeds variety Suwan 2 were sown directly into the soil. Seven days after sowing, the seedlings were thined leaving two plants per pot. The plant shoots were harvested for dry matter determination 30 days after sowing. The plant materials were dried at 70°C in on oven for one week and then weighed out for dry weight determination. The shoot dry weights were ground into meshes for plant tissue analysis. The method used for tissue mineral content was as that of Chapman and Pratt (1961). After harvest, the soil used at each pot was sampled for the analysis of available P, pH, and organic matter percentages by the method of Page (1982). The data obtained were statistically analysed.

RESULTS AND DISCUSSION

Soil Properties

With the addition of lime, cowpea residues and phosphorus to the soil, the results showed that both lime and cowpea residues increased soil pH values significantly (Table 1). Nevertheless, the addition of phosphorus into the soil gave no significant effect on soil pH. The results suggested that a large amount of Ca could possibly released by cowpea residues and did the lime. It is of great importance that cowpea residues could possibly contained a large amount of Ca as the crop plant advanced in age. The results agree with the work reported by Mengel and Kirkby (1987). Therefore it might be infered that crop residues particularly leguminous crops could possibly help in releasing a certain amount of Ca apart from other macronutrients and organic materials. The results also showed that cowpea residues

increased soil organic matter content significantly (Table 1).

Table 1. The main effects of phosphorus, cowpea residues and lime application on soil pH, % organic matter and available P in Yasothon soil after the growth of maize at the end of the experimental period.

Treatment	Soil properties		
	pH	%Organic Matter	Bray II P (ppm)
Phosphorus (kg P_2O_5 /ha)			
0	5.70	0.82	5.47
58	5.97	0.84	11.86
116	6.02	0.85	19.58
174	6.00	0.87	28.42
LSD 0.05	0.06	0.05	1.01
Cowpea residue (ton/ha)			
0	5.48	0.77	15.63
6.25	5.93	0.84	15.71
12.50	6.35	0.92	17.65
LSD 0.05	0.05	0.04	0.88
Lime (kg/ha)			
0	5.57	0.85	16.24
625	5.94	0.84	16.58
1,250	6.25	0.85	16.18
LSD 0.05	0.05	0.04	0.88

The amount of available soil P was highest with the addition of phosphrus into the soil and the cowpea residues ranked the second. This must be attributed to the amount of P released from both sources which persumably was greater for phosphorus rather than cowpea residues. However, the addition of cowpea residues to the soil improved soil pH, available soil P whilst liming did not. This could presumably be due to the amount of organic matter and P released from cowpea residues whilst lime did not. The results confirmed the work reported by Haynes (1982).

Shoot Dry Weights

For shoot dry weights, the results showed that an increase in the amount of phosphorus added to the soil increased shoot dry weights of maize plants significantly (Table 2). The effect due to phosphorus was greater than the effect due

Table 2. Shoot dry matter yields of maize as influenced by phosphorus, cowpea residues and lime application.

Treatment	Shoot Dry Matter Yields (gm/pot)
Phosphorus (kg $P_2 O_5$ /ha)	
0	1.67
58	4.79
116	5.97
174	7.55
LSD 0.05	0.86
Cowpea residues (ton/ha)	
0	4.55
6.25	5.08
12.50	5.35
LSD 0.05	0.75
Lime (kg/ha)	
0	4.83
625	5.08
1,250	5.07
LSD 0.05	0.75

to cowpea residues.The effect due to the added lime was not significant.This can be attributed to the amount of available P in the soil which was relatively low (4.41 ppm P) that is why larger level of P added to the soil gave significant differences when compared with the control treatment. The less effect of cowpea residues than phosphorus can be attributed to the lesser amount of P released by cowpea residue: than phosphorus. Therefore, to obtain better results, the amount of cowpea residues should be increased more than 12.50 ton/ha for this poor soil. There was no significant effect due to lime added to the soil on shoot dry weights although

there was an increase in the values of soil pH (Table 1). The results indicated that this soil type deposited less amount of P perhaps below critical level for crop growth. Therefore, with this type of soil, it is difficult to obtain optimum crop yield without the addition of P to the soil. Nevertheless, the addition of cowpea residues to supply P and organic matter in the soil should be of advantages.

Chemical Composition in Maize Shoots

The addition of phosphorus to the soil decreased the percentages of N,K and Ca whilst the percentages of P increased significantly (Table 3). This can be attributed

Table 3. The main effects of phosphorus, cowpea residues and lime application on the percentages of N,P,K and Ca in Maize shoots.

Treatment	%Nutrient concentration			
	N	P	K	Ca
Phosphorus (kg P2 O5 /ha)				
0	2.79	0.11	3.47	1.35
58	1.76	0.14	2.13	0.88
116	1.50	0.17	2.13	0.74
174	1.24	0.19	1.66	0.64
LSD 0.05	0.33	0.01	0.38	0.13
Cowpea residue (ton/ha)				
0	1.44	0.15	2.11	0.88
6.25	1.82	0.16	2.32	0.91
12.50	2.21	0.15	2.61	0.92
LSD 0.05	0.29	0.009	0.33	0.12
Lime (kg/ha)				
0	1.96	0.17	2.33	0.71
625	1.73	0.15	2.30	0.93
1,250	1.79	0.14	2.42	1.08
LSD 0.05	0.29	0.009	0.33	0.12

to the severe soil P deficient (4.41 ppm P). The decrease in the percentages of N,K and Ca could be attributed to the rapid growth of the crop plants resulted in the

dilution of N,K and Ca (Jarrell and Beverly, 1981). The addition of cowpea residues to the soil increased N and K percentages significantly. The increase could presumably be attributed to the cowpea residues which may supply adequate amount of N and K nutrients to the soil whilst the addition of lime decreased P percentages significantly but significantly increased Ca. The decrease in the percentages of P can presumably be attributed to the less amount of deposited soil P or perhaps some amount of lime may increased P fixation in the soil. The results confirmed the work reported by Amarasiri and Olsen (1973).

With the total uptake, the addition of P to the soil increased the total uptake of N, P, K and Ca significantly (Table 4). It is obvious that P encourages the uptake of

Table 4. The main effects of phosphorus, cowpea residues and lime application on the total uptake of N,P,K and Ca in maize shoots.

Treatment	Total nutrient uptake (mg/pot)			
	N	P	K	Ca
Phosphorus (kg P2 O5/ha)				
0	46.74	1.84	55.78	22.10
58	76.93	6.73	101.42	40.60
116	80.32	9.85	121.25	43.33
174	91.76	14.13	126.17	47.53
LSD 0.05	14.34	1.39	21.38	6.07
Cowpea residue (ton/ha)				
0	52.45	7.36	77.57	32.67
6.25	72.91	8.45	94.38	39.67
12.50	96.46	8.60	131.51	42.64
LSD 0.05	12.42	1.20	18.51	5.26
Lime (kg/ha)				
0	75.39	8.61	96.48	29.06
625	72.83	7.94	103.39	39.68
1,250	73.60	7.86	103.58	46.43
LSD 0.05	12.42	1.20	18.51	5.26

N and N encourages the uptake of K due to negative and possitive charges (Armstrong, 1988). The results also evidently shown that an increase is the amount of P added to the soil increased soil P, P concentration and dry matter yield of maize plants (Fig. 1).

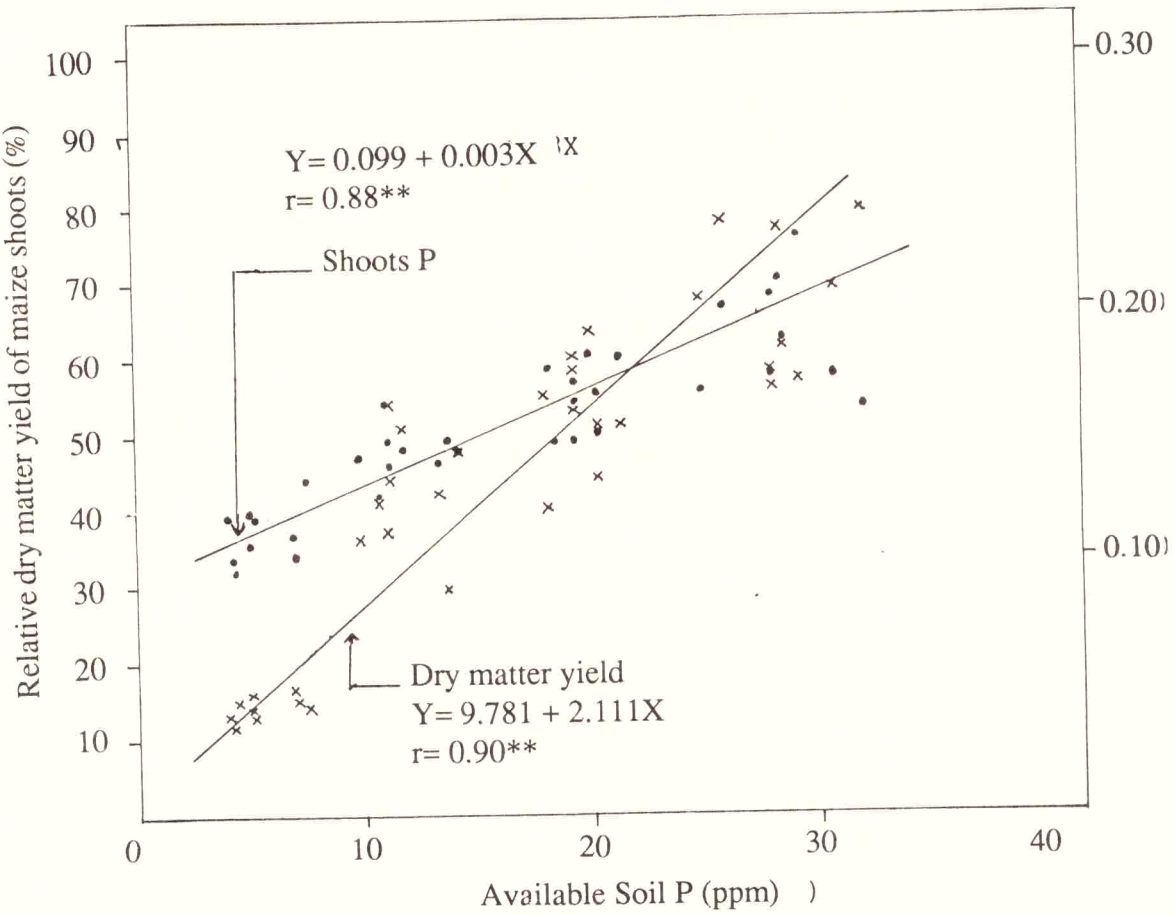

Fig. 1.The relationship between the relative dry matter yields of maize shoots and soil P levels and the relationship between the percentages of P in maize shoots and soil P levels.

The results confirmed the work reported by Fageria (1989). The addition of cowpea residues to the soil increased total uptake of N,K and Ca in maize significantly. There was a trend found with P uptake i.e. an increase in the amount of cowpea residues added to the soil increased P uptake in shoots of maize plants whist liming increased only Ca uptake. The results indicated that cowpea residues can be a better source than lime in improving the fertility of this poor soil by increasing organic matter content and available soil P.

CONCLUSIONS

To sum up, the addition of cowpea residues and lime to the Yasothon Soil increased soil pH values. Cowpea residues increased available soil P and soil organic matter whilst phosphorus significantly increased available soil P but lime did not. The application of phosphorus to the soil greatly increased maize shoot dry matter yields and cowpea residues ranked the second but lime did not. Phosphorus decreased the percentages of N,K and Ca but increased the percentages of P in the plant shoots. Cowpea residues significantly increased the percentages of N and K in shoots whilst lime significantly decreased P concentration but a reverse was with Ca. The application of P significantly increased total uptake of N,P,K and Ca in shoots of maize plants.

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