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Effect of Rock Phosphate to Corn and Groundnut on Basaltic Soil in Vietnam

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Abstract

In Vietnam, basaltic soil is rich in total phosphorus (P), but poor in available P, because of fixing. Most of crops on the soil have symptom of P deficiency. Rock phosphate (RP) was a slow release P fertilizer and has a longer residual effect. This is to research on effect of RP's to corn and groundnut on basaltic soil in Vietnam. Two parallel experiments with 9 treatments of Control, Super Single Phosphate (SSP), Vietnam RP, Morocco PR, Tunisia PR, Jordan PR, Algeria PR, Senegal PR and Togo PR were conducted during 2015-2016. The experiments were designed to Randomized Complete Block (RCB) with 4 replications and the plot area of 100 m^2. The backgrounds consisted 180 N-90 K_2O for corn and 45 N-60 K_2O for groundnut. Except control, phosphorus dose was 90 P_2O_5. Study results showed that applying 90 kg P_2O_5 in RP form improved N and P content in corn leaves, increased biomass by 20.6-22.0% and corn productivity by 7.8-15.5%. Output of 1 kg P_2O_5 in RP form was 5.2-10.4 kg corn grain. Supplying 90 kg P_2O_5 in RP form increased groundnut biomass by 43.5-48.5%, root nodulation by 109.3-115.0% and productivity by 15.5-16.8%. Efficiency of 1 kg P_2O_5 in RP form was 2.1-2.3 kg groundnut bean. The difference of corn and groundnut productivity among SSP and RP treatments was insignificant.

Keywords: Biomass; Fertilizer; Rock phosphate; Corn

Introduction

In Vietnam, basaltic soil (Rhodic Ferralsols) is rich in total phosphorus (P), but poor in available P, because of fixing by iron and aluminium [1]. Most of crops on the soil has symptom of P deficiency. Sorption of soil P is a major constraint to agricultural production, particularly those in high rainfall areas [2,3]. Deficiency of P is one of the major factors limiting crop production in the soil. Soil P exists in inorganic and organic form. Each form is a continuum of many P compounds, existing in equilibrium with each other and ranging from solution P (taken up by plants) to very stable or unavailable compounds (the most typical). Most of soil, 50% to 75% of P is inorganic [4]. Phosphorus should be added to soil so adequate levels are available for optimum crop growth and productivity. However, P fertilizer can be rapidly fixed (also referred to as sorption) in forms unavailable to plants, depending on soil pH and form of Al, Fe, or Ca content. Conversing P from unavailable form to available one usually occurs too slowly to meet crop requirements.

Corn and groundnut are main annual crops in Daklak province. These crops need high level of P for growth and development [5]. Rock phosphate (RP) is a slow P release fertilizer and has longer residual effect [6,7]. Some studies compared RP's with single Super Phosphate in their role of increasing crop yield, but a few studies have been conducted with respect to field trials [8,9]. This is to evaluate effect of some RP's to corn and groundnut on basaltic soil in Vietnam during 2015-2016.

Materials and Methods

Study site

Researching was implemented in Daklak, about 1,200 km in the south of Hanoi capital of Vietnam. Since the characteristics of the location, Daklak is affected by the tropical monsoon climate and the cool weather of the highlands. Markedly, there are two seasons: rainy season from May to October and dry season from November to April next year. These features give Daklak a special climate from other parts of Vietnam. Also, this weather is good for growing plants such as coffee, rubber trees, corn, groundnut. Basaltic soil in Daklak province has low bulk density and quite high porosity. The soil is acidic, rich in total of organic carbon, nitrogen and phosphorus, but poor in available phosphorus (Tables 1 and 2).

Materials

The varieties of corn CP888 and groundnut GV10 were used for experiments; with density of 56,000 plants ha^{-1} for corn and 266,666 plants ha^{-1} for groundnut. The types of nitrogen and potassium fertilizer were urea (46% N) and Muriate of potash (60% K_2O).

Methods

Two parallel experiments with 9 treatments for one were conducted on basaltic soil in Daklak province of Vietnam during 2015-2016. The experiments were designed to RCB (Randomized Complete Block), with 4 replications and plot area of 100 m^2. The experimental background consisted 180 kg N - 90 kg K_2O for corn and 45 kg N - 60 kg K_2O for groundnut. Except treatment of control, phosphorus dose of each other were 90 P_2O_5 (Table 3).

Results

The effect of RP's on corn

The data from Table 4 shows that corn biomass from experimental treatments ranged from 282.6 to 345.2 g $tree^{-1}$. Applying RP's increased corn biomass by 20.6-22.2% compared to that of control. The content of N and P in corn leaves was different among experimental treatments,

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Depth (cm)	Bulk density (g cm^{-3})	Density (g cm^{-3})	Porosity (%)
0-25	0.91	2.65	65.7
26-60	1.05	2.67	60.7
61-100	1.02	2.67	61.8

Table 1: Physical characteristics of soil at study site before experiment.

Depth(cm)	pH KCl	OC (%)	Total N (%)	Total P_2O_5 (%)	Available P_2O_5 (mg kg^{-1})	Al^{3+} (mg kg^{-1})	Fe^{3+} (mg kg^{-1})
0-25	4.32	3.15	0.192	0.21	44.6	28.6	53.2
26-60	4.36	1.22	0.086	0.2	55.7	20.2	59.4
61-100	4.39	0.54	0.035	0.2	11.5	17.3	61.4

Table 2: Chemical characteristics of soil at study site before experiment.

Treatment	Type of fertilizer	P_2O_5 in fertilizer (%)	Rate of fertilizer (kg ha^{-1})	Rate of P_2O_5 (kg ha^{-1})
T1	Without P (Control)	-	-	-
T2	SSP	18	500	90
T3	Vietnam RP	30	300	90
T4	Morocco RP	30.6	294.1	90
T5	Tunisia RP	30	300	90
T6	Jordan RP	30.7	293.2	90
T7	Algeria RP	29	310.3	90
T8	Senegal RP	30	300	90
T9	Togo RP	35.6	252.8	90

Table 3: The treatments of experiment.

Treatment	Biomass		N (%)	P (%)
	(g $tree^{-1}$)	%		
Without P (Control)	282.6 a	100	2.11	0.14
Super Phosphate	345.2 b	122.2	2.19	0.23
Vietnam RP	345.2 b	122.2	2.17	0.21
Morocco RP	344.1 b	121.8	2.16	0.21
Tunisia RP	342.3 b	121.1	2.18	0.22
Jocdan RP	340.6 b	120.5	2.16	0.22
Algeria RP	344.9 b	122	2.16	0.21
Senegal RP	343.8 b	121.7	2.18	0.2
Togo RP	345.0 b	122.1	2.17	0.21

Means with the same letter are not significantly different from each other, $p<0.05$

Table 4: The effect of RP on biomass end nutrient content in corn leaves at flowering.

with the lowest found out in control. Applying 90 P_2O_5 increased N and P content in leaves by 0.05-0.8% and 0.06-0.09%, respectively. Table 5 shows that applying P fertilizer increased corn yield by 7.8-15.9%. Among which, SSP treatment had highest productivity, with 6,983 kg ha^{-1}. The productivity from RP treatments were 6,538-6,957 kg ha^{-1}, 7.8-15.5% higher than control. Notably, the difference of productivity among SSP and RP treatments was not much. Even, some RP treatments such as Vietnam RP, Tunisia RP and Togo RP got quite high productivity, equated to SSP. The efficiency of 1 kg P_2O_5 was 10.7 kg grain corn for SSP and 5.2-10.4 kg for RP's. Thus, applying RP's increased biomass, leaf nutrient content and productivity of corn.

The effect of RP's on groundnut

Under the RP's applied biomass and root nodulation of groundnut increased by 43.5-48.5% and 109.3 - 115.0%, respectively. Difference of biomass and root nodulation among SSP and RP treatments was insignificance (Table 6). The data from Table 7 presented that groundnut yield increased 15.5-18.3% under 90 kg P_2O_5 applied. In that, SSP increased by 18.3% and RP's improved by 15.5-16.8%. The efficiency of 1 kg P_2O_5 of RP's was 2.1-2.3 kg groundnut. There was no difference of productivity among SSP and RP treatments.

Discussion

Applying P fertilizer increased biomass, leaves nutrient content and productivity of corn. The difference of corn biomass and nutrient content in leaves among treatments of SSP and RP's was insignificant. Improvement in yield and yield components of corn has been recorded earlier with application of P. The yield of corn increased significantly with P level of 90 kg P_2O_5 ha^{-1} [10-12]. Application of 90 kg P_2O_5 ha^{-1} to corn crop increased grower's income as compared to the lower rates of P (90>60>30 P_2O_5) [13]. Significant differences could not be established for the P sources, any of the rock phosphate could be used as P source for corn [14].

Applying RP's improved number of root nodulation of groundnut, which can absorb N_2 from atmosphere. Applying P fertilizer as SSP or RP's increased rhizomes [15]. Rock phosphate stimulated root nodulation, enhanced soil microbiological activity, improved N and P accumulation. It is possible that root diseases, caused e.g., by nematodes may be reduced, so productivity and quality of groundnut were improved [16].

Treatment	Yield		Efficiency (kg corn grain per kg P_2O_5)
	(kg ha^{-1})	%	
Without P (Control)	6.024 a	100	-
Super Phosphate	6.983 b	115.9	10.7
Vietnam RP	6.957 b	115.5	10.4
Morocco RP	6.582 b	109.3	6.2
Tunisia RP	6.915 b	114.8	9.9
Jocdan RP	6.603 b	109.6	6.4
Algeria RP	6.494 b	107.8	5.2
Senegal RP	6.538 b	108.5	5.7
Togo RP	6.902 b	114.6	9.8

Means with the same letter are not significantly different from each other, p<0.05

Table 5: Corn yield and effectiveness of phosphate fertilizer.

Treatment	Biomass		Root nodulation	
	(g/tree)	%	(number/plant)	%
Without P (Control)	42.3 a	100	33.4 a	100
Super Phosphate	64.8 b	153.2	72.6 b	217.4
Vietnam RP	61.5 b	145.4	70.5 b	211.1
Morocco RP	60.7 b	143.5	71.3 b	213.5
Tunisia RP	62.2 b	147	69.9 b	209.3
Jocdan RP	62.8 b	148.5	71.6 b	214.4
Algeria RP	61.9 b	146.3	71.8 b	215
Senegal RP	61.3 b	144.9	70.7 b	211.7
Togo RP	62.0 b	146.6	71.2 b	213.2

Means with the same letter are not significantly different from each other, p<0.05

Table 6: The effect of rock phosphate on biomass and number of root node.

Treatment	Yield		Efficiency (kg groundnut bean per kg P_2O_5)
	(kg ha^{-1})	%	
Without P (Control)	1237 a	100	-
Super Phosphate	1463 b	118.3	2.5
Vietnam RP	1429 b	115.5	2.1
Morocco RP	1437 b	116.2	2.2
Tunisia RP	1441 b	116.5	2.3
Jocdan RP	1445 b	116.8	2.3
Algeria RP	1438 b	116.2	2.2
Senegal RP	1440 b	116.4	2.3
Togo RP	1442 b	116.6	2.3

Means with the same letter are not significantly different from each other, p<0.05

Table 7: Groundnut yield and effectiveness of phosphate fertilizer.

Conclusions

On basaltic soil in Vietnam, applying 90 kg P_2O_5 in RP form improved N and P content in corn leaves, increased biomass by 20.6-22.0% and corn productivity by 7.8-15.5% in comparison with the control. The output of 1 kg P_2O_5 in RP's form was 5.2-10.4 kg corn grain. Supplying 90 kg P_2O_5 in RP form increased groundnut biomass by 43.5-48.5%, root nodulation by 109.3-115.0% and productivity by 15.5-16.8%. The efficiency of 1 kg P_2O_5 in RP's form was 2.1-2.3 kg groundnut bean. The difference of corn and groundnut productivity among SSP and RP treatments was insignificant.

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