Phosphorus Fertilization Strategies for Groundnut Grown on Upland Acid Soils in Nghe An Province

By Nguyen Cong Vinh

Sustained cash crop production in the acid uplands of North Vietnam can be seriously hampered by the strong phosphate (P) adsorption capabilities of the region's soils. Insight into the nutrient demand of groundnut (peanut) is gained through this series of laboratory and field studies.

Groundnut is an important cash crop for Nghe An Province in North Vietnam, which has a total land area of 1.6 million hectares (M ha) and 180,000 ha agricultural land. Groundnut area in Nghe An is about 29,000 ha and total production was 32,000 tonnes (t) in 1999. It is expected to increase to about 40,000 t by 2010 (Vu Nang Dung, 2001). Groundnuts are cultivated as a monocrop, intercropped with perennial crops, and in peanut-bean-maize rotations. Low soil P status is the main production constraint because of strong P sorption in Ferralsols, the predominant soil type.

This study examined P sorption characteristics of the predominant soil type, groundnut response to applied P, and compares P management strategies for locally available nutrient sources.

Materials and Methods

In a soil P sorption study, potassium phosphate (KH_2PO_4) in 0.01M calcium chloride ($CaCl_2$) was added to soil samples at rates of 0, 25, 50, 100, 200, 400, 2,000, and 4,000 µm P/g soil. The soils were shaken, centrifuged, and the P content in solution was measured colorimetrically. Adsorption was determined by the difference between the amount of P added and the amount remaining in solution.

Field experiments were carried out in the spring seasons in 1997 and 1998 at Nghia Dan District, (19°00-19°32'N and 104°10'-105°34'34''E) on a Ferralsol derived from basaltic rock (Hyperdystric rhodic Ferralsol, FAO-UNESCO; Typic Paleustult, USDA Soil Taxonomy, see **Table 1**). These clay soils are strongly acidic and

Table 1. Soil properties at the experimental site, Nghe An Province.

	Depth, cm		
Parameter	0 - 9	9 - 28	28 - 120
pH_{H_2O} (1:5)	4.10	4.30	4.10
Total C, %	1.48	0.87	0.45
Total N, %	0.137	0.129	0.095
Total P, mg/kg	2.8	2.8	2.8
Total K, mg/kg	1.0	0.9	1.0
Available P, mg/kg (Bray II)	3.8	2.0	2.7
K, cmol/kg	0.11	0.08	0.08
Ca, cmol/kg	2.77	2.15	2.15
Mg, cmol/kg	2.15	2.38	1.61

Table 2. Characteristics of local P-containing sources, Nghe An Province.

Source	Year	Concentration of nutrients in fertilizer, % pH	N	P_2O_5	K_2O	CaO	MgO	Moisture, %
SSP	–	2.7	–	16.0	–	21.8	1.35	–
FMP	–	7.3	–	15.0	–	24.4	15.9	–
FYM	1997	–	0.31	0.27	0.18	0.22	0.12	37.5
FYM	1998	–	0.42	0.31	0.10	0.42	0.26	30.5

contain small amounts of organic matter, plant available nitrogen (N), P, potassium (K), magnesium (Mg), and calcium (Ca).

The goals in the field study were to: (a) determine the potential response of groundnut to P fertilizer and (b) compare locally available P sources [i.e., single superphosphate (SSP) and fused magnesium phosphate (FMP), and farmyard manure (FYM)] (**Table 2**).

In the P rate study, six rates (0, 30, 60, 90,120, and 150 kg P_2O_5/ha) were tested with SSP as the source.

Table 3. Outline of treatments used in the P source comparison study, Nghe An Province.

Treatment	FYM, t/ha	P fertilizer FMP	SSP	N	K_2O
1. Control	0	0	0	0	0
2. FMP	0	90	0	20	60
3. SSP	0	0	90	20	60
4. FYM	10	0	0	20	60
5. FYM + FMP	10	90	0	20	60
6. FYM + SSP	10	0	90	20	60

For the P source comparison, an outline of the fertilizer treatments is provided in **Table 3**. Treatments with FYM first had the manures spread along shallow ditches created in the field. Those treatments with FYM and P fertilizer had both products added to the ditches which were then covered with fine soil at planting time. All treatments, except the control, also received 20 kg N, 60 kg K_2O, in the form of urea and potassium chloride (KCl), as well as 500 kg lime/ha. The lime was broadcast and incorporated during initial land preparation before planting.

A local groundnut variety (var. Sen Lai) was planted in rows 30 cm apart with 15 cm between hills. A randomized complete block design with four replications was used. Plot size was 20 m^2. Two to three seeds were sown per hill and plants were thinned to one or two plants after establishment. Aboveground portions were recycled for the next crop and below ground portions were removed and separated from the pods.

Air temperature ranged from 18 to 29°C in 1997 and from 19 to 30 in 1998. Air humidity ranged between 80 to 90% in 1997 and between 73 to 90% in 1998 (**Figure 1**). Total rainfall was 1,778 mm in 1997 and 1,137 mm in 1998. During the wet season (late April to October) air temperature was also high, increasing the rate of evaporation. Total

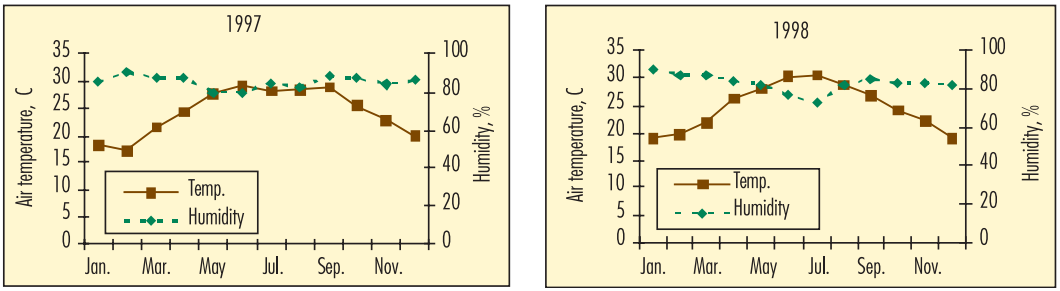

Figure 1. Seasonal changes in air humidity and temperature in Nghia Dan, Nghe An Province.

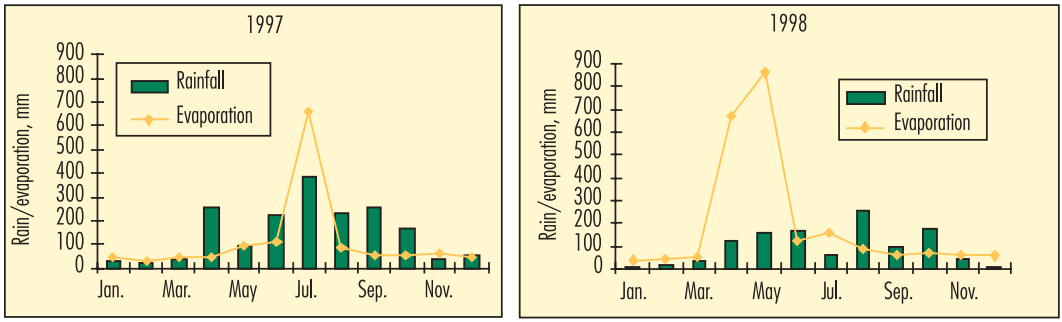

Figure 2. Seasonal changes in rainfall and evaporation in Nghia Dan, Nghe An Province.

evaporation was 1,321 and 2,262 mm in 1997 and 1998, respectively (**Figure 2**). As a result, precipitation was greater than evaporation in 1997 and the opposite was true for 1998.

Results

The P sorption model, represents the test soil's ability to 'fix' applied P and highlights the high P requirement for crops grown on this soil type (**Figure 3**). At low concentrations of applied P (25 to 100 mg/kg), 99.8% was adsorbed, while at high concentrations (4,000 mg/kg) 46.5% was adsorbed. High clay content, most likely kaolinitic clay, and the presence of iron (Fe) and aluminum (Al) oxides are responsible for this high affinity for P (Fairhurst and Warren, 1992; Le Van Can, 1979; Hoang Van Huay, 1979).

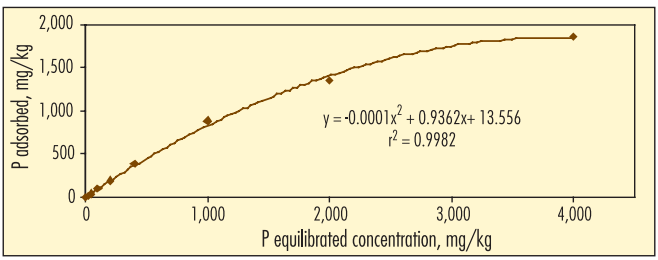

Figure 3. Phosphorus absorption of the Ferralsol test soil located at Nghia Dan, Nghe An Province.

There was a large response to P, applied as SSP. Pod yield was significantly correlated with P fertilizer application rate (**Figure 4**). The relationship between yield and the amount of P applied was fitted to a Mitscherlich equation:

$$y=a-b^{exp(-cx)}$$

where y is seed yield (t/ha), x is P_2O_5 rate (kg/ha), and a, b, and c are coefficients. Coefficient a estimates the asymptote or maximum yield plateau (t/ha), coefficient b estimates the maximum yield increase to added P (t/ha), and coefficient c describes the shape of the response curve. Fitting the relationship between spring peanut yield and P rate resulted in the following functions:

$$(1997)\ y = 0.993(1-0.303^{\exp(-0.021 \times P\ rate)})$$

$$(1998)\ y = 0.823(1-0.271^{\exp(-0.028 \times P\ rate)})$$

The maximum yield increase to added P (coefficient b) was 0.303 t/ha (1997) and 0.271 t/ha (1998) indicating that yield potential in 1998 was lower than in 1997, which is likely due to the relative amounts of rainfall during the two growing conditions.

Over the two seasons, both pod and seed yield reached their

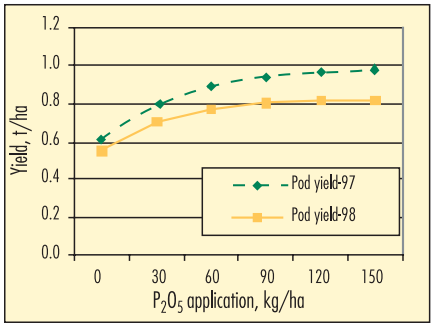

Figure 4. Groundnut pod yield response to SSP application, Nghe An Province.

maximum at 90 kg P_2O_5/ha (**Table 4**). Seed out-turn seemed to be positively affected by application rates of 60 kg or higher and agronomic efficiency for P fertilizer also reached its maximum at the 90 kg application rate.

Groundnut showed a strong response to P fertilizer regardless of source. Depending on the crop year, application of fertilizer P alone increased pod yield by 26 to 66% and seed yield by 24 to 102% (**Table 5**). Application of SSP along with 500 kg lime/ha gave a higher pod and seed yield than FMP plus lime. It is reasoned that the higher pH of the FMP source, which is already rich in Ca oxide (CaO) and Mg oxide (MgO), may be a less plant available P source, especially when it is combined with 500 kg lime/ha.

The FYM treatment performed well and this was likely a result of additional nutrient supply. FYM nutrient content was estimated at 20 kg N/ha, 11 kg K_2O, 14 kg CaO, and 8 kg MgO in 1997. For 1998, it was 29 kg N/ha, 7 kg K_2O, 29 kg CaO, and 18 kg MgO. Yield increased from 0.86 and 0.71 t/ha in the control to 1.57 and 1.44 t/ha with the FYM treatment for the 2 years. Application of organic manures on these soil types could also be responsible for reduced P adsorption as evidenced by research on coffee soils in Nigh Dan (Nguyen Khan Hoa, 1994). In that pot study, P adsorption in the control soil was measured at 99.7%, but addition of FYM decreased it to 87.2%.

The highest seed and pod yields were obtained by combining fertilizer P and FYM, where FYM + FMP appeared to have a slight advantage over FYM + SSP, particularly for increasing pod yield. Groundnut seed out-turn was

Table 4. Mean groundnut (var. Sen Lai) yield (1997, 1998) at six rates of SSP fertilizer, Nghe An Province.

P_2O_5 rate, kg/ha	Relative yield, %		Yield, t/ha		Out-turn[1]	Agronomic efficiency[2] for P
	Pods	Seed	Pods	Seed		
0	100	100	0.60	0.47	0.78	–
30	118	113	0.71	0.53	0.75	2.0
60	138	143	0.83	0.67	0.81	3.3
90	160	166	0.96	0.78	0.81	3.4
120	150	153	0.90	0.72	0.80	2.1
150	142	145	0.85	0.68	0.80	1.4
LSD (p = 0.05)			0.03	0.03		

[1]Ratio of seed yield to pod yield.
[2]kg seed yield increase per kg nutrient added.

Table 5. Effect of five fertilizer treatments supplying 90 kg P_2O_5/ha and the zero P control on the groundnut seed and pod yield as well as percent of filled pods, Nghe An Province.

Treatment	Seed yield (t/ha)		Pod yield (t/ha)		Out-turn[1]		Filled pods (%)	
	1997	1998	1997	1998	1997	1998	1997	1998
1. Control	0.37	0.34	0.86	0.71	0.43	0.48	60.8	60.2
2. FMP	0.46	0.41	1.08	0.95	0.42	0.43	73.1	74.5
3. SSP	0.59	0.51	1.39	1.18	0.42	0.43	66.9	73.6
4. FYM	0.85	0.82	1.57	1.44	0.54	0.57	76.4	74.3
5. FYM + FMP	0.90	0.87	1.78	1.70	0.50	0.51	75.3	72.1
6. FYM + SSP	0.90	0.84	1.64	1.57	0.55	0.54	75.0	67.4
LSD (p = 0.05)	0.03	0.04	0.05	0.17	0.03	0.03	1.9	1.8

[1]Ratio of seed yield to pod yield.

positively influenced by FYM application, while the percentage of filled pods increased with either fertilizer P or FYM addition.

Groundnut showed a positive response to P in Vietnam studies on upland acid soils.

Conclusions

Hyperdystri-Rhodic Ferralsols in Nghia Dan are characterized by low pH, organic matter, and available P and K. Groundnut grown on these soils have a strong response to inorganic P as well as nutrients supplied by FYM. In hot, dry weather as in 1997 and 1998, application of FYM had the biggest impact on yield compared with SSP and FMP products. **However, the combination of P fertilizer (90 kg P_2O_5/ha) and FYM gave the highest yields and should be recommended to farmers.** **BCI**

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