Indian Journal of Natural Rubber Research, 8(2) : 130-134, 1995

EFFECTS OF LIMING ON NUTRIENT UPTAKE, BIOMASS PRODUCTION AND NODULATION IN *PUERARIA PHASEOLOIDES*

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Philip, A., Joseph, M., Punnoose, K. I. and Antony, A. P. (1995). Effects of liming on nutrient uptake, biomass production and nodulation in *P. phaseoloides*. *Indian Journal of Natural Rubber Research*, 8(2) : 130-134.

Potculture experiments were conducted to study the effects of liming on the growth of *Pueraria phaseoloides* and on the changes in soil chemical properties. Liming significantly increased the dry matter production and nodulation of *P. phaseoloides*. The availability of P, K, Ca and Mg in soil increased significantly by lime application. Liming showed a positive effect on the uptake of N, P, Ca and Mg but had negative effect on the uptake of K.

Key Words : Lime requirement, Dry matter production, Nodulation, Cover crop, *Rhizobium*, *P. Phaseoloides*

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INTRODUCTION

Establishment of leguminous cover crops in the immature phase is one of the important agronomic practices followed in rubber plantations. These cover crops contribute much to the nitrogen requirement of rubber plants (Shorrocks, 1965) through the fixation of atmospheric nitrogen in the root nodules by symbiotic nitrogen fixing bacteria. These bacteria are reported to be sensitive to soil acidity and prefer a neutral pH (Alexander, 1967). In India rubber is mainly grown in acidic soil and liming will have a beneficial effect on bacterial population. Also liming is one of the management practices through which the productivity of the acid soils can be enhanced by overcoming the unfavourable soil characters. Earlier reports also show that legumes usually make better use of atmospheric nitrogen in limed soils (Watson, 1957). According to Chongkew (1983), liming improved the shoot growth and nodulation in peanut and cowpea. The present experiment was undertakn to study the effect of liming and consequent changes in soil pH on the availability of nutrients and on the nodulation and biomass production of the cover crop *P. phaseoloides*.

MATERIALS AND METHODS

Experiment 1

A pot culture experiment in completely randomised block design with six replications was conducted to study the effect of liming on nodulation of the leguminous cover crop *Pueraria phaseoloides* using the soil collected from the experiment station of the Rubber Institute of India, Kottayam. The pH of the soil was 4.8. The lime requirement (LR) of the soil was estimated as per the procedure given by Bear (1964) and found to be 1275 kg per ha.

Glazed porcelain pots of 30 cm diameter and 30 cm depth were used for the experiment. Each pot was filled with 17.5 kg of soil. The treatments of five levels of lime, (0, 25, 50, 75 and 100 per cent LR) were incorporated to each pot and kept for one week for proper reaction. Seeds of *P. phaseoloides* pre-treated with hot water were inoculated with *Rhizobium* culture and sown in the pots. Three weeks later the seedlings were thinned down retaining five per pot. The plants were regularly watered. On the 45th day the plants were uprooted and nodules were collected from each pot. Nodule number and nodule weight were recorded.

Experiment 2

A second experiment with the same treatment combination was conducted to study the effect of liming on the availability of nutrients and growth of *P. phaseoloides*. The pots were filled with soil collected from the same field. The treatments of five levels of lime (0, 25, 50, 75 and 100 per cent LR) as in the first experiment were incorporated to each pot and kept for one week for proper reaction. Seeds of *P. phaseoloides* pretreated with hot water were inoculated with *Rhizobium* culture and sown in the pots. Three weeks later the seedlings were thinned down to five per pot. The recommended doses of P and K were supplied through Mussoorie rockphosphate and muriate of potash at the rate of 25g and 8g, respectively to each pot. Nitrogen was not supplied to the plants. The plants were regularly watered. Three months after sowing, plants were uprooted. Shoot and root of the plants were separately collected from each pot and dry matter production was recorded. Soil sample from each pot was also collected. Analyses of the soil samples were carried out as per the procedure outlined by Jackson (1967) and the plant samples were analysed for the total nutrient concentration as per Piper (1966).

RESULTS AND DISCUSSION

Experiment 1

Table 1 shows the effect of liming on nodulation of *P. phaseoloides*. Liming significantly increased the number and weight of nodules. The control pot recorded on an average seven nodules per pot whereas in the 100 per cent LR pots, 44 nodules per pot were recorded. The weight of nodules increased from 28 mg in control (no lime) to 312 mg in 100 per cent LR treatments. Similar trend was also reported by Hawan and James(1980).

Table 1. **Effect of liming on nodulation by *P. phaseoloides***

Treatment (% LR)	Nodules Number	weight (mg)
0	7(1.4)	23 (4.6)
25	14 (2.8)	47 (9.4)
50	17 (3.4)	65 (13.0)
75	26 (5.2)	98 (19.6)
100	44 (8.8)	312 (62.4)
CD (P = 0.05)	6.38	79.02

Figures in parentheses are the number and weight of nodules per plant

The increase in nodulation with higher doses of lime may be due to the fact that soil pH governs root nodulation. The process of infection is sensitive to pH. According to Epstein (1972), at low pH root hairs fail to curl and become infected by *Rhizobium* . When the pH increases, the root hairs were promptly curled and become infected.

Experiment 2

The available P, K, Ca and Mg of the initial soil were 3.00, 4.75, 24.10 and 1.79 mg/100 g soil respectively. The pH was 4.8 and the percentage of organic carbon was 2.62. Table 2 shows the effect of liming on soil pH and the availability of nutrients after three months at the time of harvesting of the crop. Liming steadily increased the pH. The control pot had a pH of 4.61 and

Table 2. Effect of liming on pH and availability of nutrients in soil

Treatment	pH	O.C	Available nutrients (mg/100 g soil)			
(% LR)		(%)	P	K	Ca	Mg
0	4.61	2.58	4.42	6.66	24.54	1.61
25	5.71	2.78	5.58	6.71	86.87	1.97
50	6.01	2.72	5.83	7.21	111.08	2.10
75	6.64	2.69	5.33	7.28	155.45	2.40
100	7.05	2.53	6.33	9.37	191.37	2.56
CD (P = 0.05)	0.15	NS	0.83	1.69	15.14	0.33

that of 100 per cent LR treatment had a pH of 7.05. The organic carbon content of the soil was not influenced by liming. It was found that lime application increases the availability of P, K, Ca and Mg. Similar results were reported by Bishnoi *et al.* (1988) and Gupta *et al.* (1989). The increased P availability might be due to the precipitation of aluminium and iron as their hydroxides on increasing the pH, which releases the fixed phosphates (Mandal *et al.*, 1975). The increase in available K by liming can also be explained on the basis that release of K from non-exchangeable fraction to avilable pool gets accelerated when acid soils are limed. The increase in Ca and Mg can be because of the movement of higher amounts of these cations from the lime particles to the exchange sites of the soil and dominance of these bases in the exchange complexes as expected in liming (Mandal *et al.*, 1975).

The effect of liming on dry matter production is presented in Table 3.The dry matter production increased with increasing levels of lime, but the effect was highly significant only at 100 per cent LR treatment.

Table 3. **Effect of liming on dry matter production of *P. phaseoloides***

Treatment	Dry weight (g/pot)		
(% LR)	Shoot	Root	Total
0	19.75	4.19	23.94
25	19.68	4.03	23.71
50	20.26	4.38	24.64
75	20.88	4.87	25.75
100	25.05	6.02	31.07
CD (P=0.05)	2.96	0.97	3.39

Changes in nutrient concentration of the root and shoot portion of *Pueraria* by lime application is given in Table 4. The N, P and Mg content in the shoot was not influenced by liming. The Ca concentration was increased whereas the K concentration decreased with the increasing levels of lime. In root also the N, P and Mg concentration did not significantly increase by lime application. The Ca concentration increased whereas the K concentration decreased significanly by the treatment. The decrease in nutrient concentration except in the case

Table 4. Effect of liming on the nutrient concentration of the shoot and root of *P. phaseoloides*

Treatment	Nutrient concentration %				
(% LR)	N	P	K	Ca	Mg
Shoot					
0	3.46	0.19	1.40	1.60	0.32
25	3.21	0.19	1.26	1.75	0.32
50	3.45	0.20	1.15	1.79	0.32
75	3.46	0.18	1.08	1.86	0.30
100	3.47	0.18	0.94	1.88	0.30
CD (P = 0.05)	NS	NS	0.24	NS	NS
Root					
0	2.16	0.14	0.59	0.73	0.21
25	2.36	0.14	0.42	0.89	0.22
50	2.27	0.14	0.44	0.86	0.24
75	2.37	0.13	0.44	0.90	0.23
100	2.43	0.14	0.40	0.93	0.26
CD (P = 0.05)	NS	NS	0.09	0.12	NS

of Ca with liming might be due to the dilution caused by the increase in dry matter produced at higher levels of liming (Chew *et al.*, 1980).

Influence of lime application on the uptake of nutrients is given in Table 5. N, P, Ca and Mg uptake in shoot increased with increasing levels of lime and the highest uptake was observed in 100% LR. Potassium uptake was found to decrease with increasing levels of lime. In case of root uptake all the nutrients recorded higher values with increasing levels of lime. With the increased levels of lime the total uptake of N, P, Ca and Mg increased whereas that of K decreased. Similar results were reported earlier by many workers (Watson, 1960; Bishnoi *et al.*, 1988 and Choudhary and Bordoli, 1993). The increase in N uptake by liming may be attributed to increased activity of nitrifying bacteria resulting in mineralization of organically bound nitrogen contributing to higher availability of N. Mineralization of organic P and release of P from Al-P and Fe-P fractions due to the repression of the activity of Al and Fe at higher pH could have contributed to the higher P uptake by plants. The decrease in K uptake with higher levels of lime might be due to the antagonistic effect of high levels of Ca in the soil as well as in the plant.

Table 5. Effect of liming on uptake of nutrients by *P. phaseoloides*

Treatment	Nutrient (mg)				
(% LR)	N	P	K	Ca	Mg
Shoot					
0	680	36	275	310	64
25	630	37	233	346	63
50	696	41	260	350	63
75	720	38	225	390	63
100	870	44	233	470	72
CD (P = 0.05)	115.80	NS	NS	NS	7.23
Root					
0	91	5.90	24	30	8.67
25	94	5.60	16	36	8.83
50	96	6.10	19	37	10.05
75	116	6.16	21	44	10.73
100	146	8.20	24	56	15.00
CD (P=0.05)	24.75	1.36	5.23	9.56	2.75
Total					
0	771	42	299	340	72.67
25	724	33	249	382	71.83
50	792	47	279	387	73.05
75	836	44	246	433	73.73
100	1016	52	257	526	87.00
CD (P = 0.05)	121.41	NS	NS	56.63	8.48

CONCLUSIONS

Studies on the effect of liming on the availability of nutrients and on the nodulation and growth of the leguminous ground cover crop *Pueraria phaseoloides* revealed that liming increased the availability of P, K, Ca and Mg in soil. The rate of nodulation was influenced by liming as evidenced through the increase in nodule number and nodule weight achieved through lime application. The dry matter production significantly increased at 100 per cent LR. The uptake of the nutrients N, P, Ca and Mg by *Pueraria* increased and that of K decreased with increasing levels of lime.

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