Natural Rubber Research, **22** (1&2): 55-63, 2009

EFFECT OF LIMING ON THE AVAILABILITY OF NUTRIENTS AND GROWTH OF YOUNG RUBBER

Mercykutty Joseph, V. K. Syamala and K. I. Punnoose

Rubber Research Institute of India, Kottayam- 686 009, Kerala, India

Joseph, M., Syamala, V.K. and Punnoose, K.I. (2009). Effect of liming on the availability of nutrients and growth of young rubber. *Natural Rubber Research*, **22**(1 & 2): 55-63.

A field experiment was conducted for seven years from planting in young rubber in the replanting field of a large estate in the traditional rubber growing tract to study the effect of liming on the availability of nutrients and growth of rubber (*Hevea brasiliensis*). Lime alone, fertilizer alone as per standard recommendation and graded levels of lime in combination with fertilizer were compared with no-lime and no-fertilizer control. Liming improved the growth of plants which was significantly evident from the fifth year onwards. Fertilizer and lime, alone or in combination were significantly superior to the control. Lime alone was found to be as good as fertilizer alone treatment during the fifth year indicating the beneficial effect of liming in these acid red ferruginous soils. Later, during the sixth and seventh years, liming at 75 or 100 per cent of lime requirement along with fertilizer was significantly superior indicating the beneficial effect of liming in improving the availability of nutrients and growth of plants.

Analysis of soil samples during the fifth year of experimentation indicated that the pH of the soil changed from very strongly acidic to moderately acidic. Available P and K status were significantly improved by liming. Liming significantly improved the exchangeable Ca status of the soil. The exchangeable Mg and K were improved by fertilizer alone or lime and fertilizer treatments. However, application of lime alone reduced the availability of Mg indicating antagonistic effect of excessive Ca on Mg availability. Exchangeable Al content in the soil was significantly reduced by lime alone or lime at 75 or 100 per cent lime requirement along with fertilizer treatments. Leaf Ca concentration increased with liming and significant difference was recorded during the seventh year of the experiment.

Keywords: Exchangeable aluminium, Liming, Shell lime, Soil acidity, Red ferruginous soils, Young rubber.

INTRODUCTION

Soil acidity has been recognized as an important agricultural problem in the tropics (Sanchez, 1976; Tisdale *et al.*, 1985). Low nutrient status and the presence of toxic elements, particularly Al are major constraints to intensive crop production in the acid soils (Adams, 1981). Under heavy rainfall conditions, all the exchangeable bases (Ca, Mg and K) and salts are leached from the soil profile leaving behind materials rich in Al and Fe oxides which render the soil acidic and infertile.

Soils in the traditional rubber cultivation belt are mainly red ferruginous dominated by Fe and Al oxides and hydrous oxides and

Correspondence: Mercykutty Joseph (Email: mercyjoseph@rubberboard.org.in)

kaolinite clay (Krishnakumar, 1989; Karthikakuttyamma *et al.*, 2000). The soil is acidic in reaction and the pH values range from 4.5 – 5.5 in the surface layer. Extremely acid soils (pH < 4.5) occur in some parts of Kanyakumari, Thiruvanathapuram, Kollam, Kottayam and Ernakulam districts covering nine per cent of the area (NBSS and LUP, 1999). In most of these soils, acidity is produced due to the presence of exchangeable Al^{3+} along with the loss of cations through erosion and leaching and also by crop removal. Suresh *et al.* (1994) reported that the exchangeable Al in the surface (0-25 cm) soil ranged from 0.36 to 0.98 m.eq/100 g and the highest concentration ranging from 0.58 – 2.23 m.eq/100 g soil was recorded in the subsurface layer (50-75 cm). Aluminium toxicity can be corrected by liming to a pH of 5.5 to 6, when exchangeable Al gets precipitated as Al hydroxides (Kamprath, 1970). In highly weathered Oxisols and Ultisols with predominance of hydrous oxides of Fe and Al, a pH of around 5.5 and exchangeable Al less than 20 per cent of the effective cation exchange capacity is reported to produce satisfactory crop growth (Adams, 1984).

In the traditional belt, rubber is being cultivated in repeated cycles in the same soil, leading to considerable depletion of the base reserve and significant reduction in the pH of the soil, rendering the soil less productive. Karthikakuttyamma (1997) reported that due to the continuous cultivation of rubber, the pH of the soil has been reduced significantly and that around 1260 kg of Ca is being depleted from the soil in one cultivation cycle through wood during replanting. Liming is recommended in the management of soil to correct the adverse soil reaction as well as to increase the exchangeable base reserve. Liming is a common practice among farmers for most of the crops in this region. However, in rubber, experimental evidence to recommend liming is lacking. Hence, the present experiment was conducted to study the effect of liming on soil properties, availability of nutrients and growth of young rubber.

MATERIALS AND METHODS

A field experiment was initiated during 1998 in a replanting field of a large estate in Central Kerala planted with clone RRII 105. The budgrafts raised in polythene bags were planted during June 1998. The experiment was laid out in randomised block design with seven treatments and three replications. The plot size was 24 plants in three rows and observations were recorded from the eight plants in the middle row. The treatments were no-lime and no-fertilizer (control), lime alone @ 100 per cent lime requirement (LR), lime @ 25, 50, 75 and 100 per cent LR in combination with fertilizer and fertilizer alone. The lime requirement of the soil was estimated by Shoemaker Method (Shoemaker *et al.*, 1961) and exchangeable Al method (Kamprath, 1970). The LR lime requirement by Shoemaker Method was very high and by exchangeable Al method comparatively low. The lime requirement in tonnes per hectare for a stand of 450 plants per hectare was converted for the effective area of the young plants. Accordingly the full LR was only 500 g of powdered shell lime per plant. Powdered shell lime as per the treatments was incorporated in the basin of the individual plants during September, three weeks before the application of the first dose of fertilizer. Lime treatments were given in alternate years.

Subsequent applications of lime were carried out during April-May season, two to three weeks prior to the pre-monsoon fertilizer application. Regular fertilizer applications as per the recommendation of RRII (40:40:16:6 kg/ha/year N, P, K and Mg) were followed (Karthikakuttyamma *et al.*, 2000). The recommended doses of fertilizers were applied during April-May and September-October. A gap of 15-20 days was provided between lime incorporation and fertilizer application. From the second year, annual girth of the plants was recorded during December every year at 150 cm height above the bud union. Soil samples were collected during second year (1999) and fifth year (2002) and analysed for pH, available nutrients, CEC, exchangeable cations and Al, by standard methods outlined in Jackson (1958). The leaf samples were collected during the fifth (2002) sixth (2003) and seventh (2004) year of the study and analysed for the total nutrient concentration (Piper, 1966).

RESULTS AND DISCUSSION

Analysis of the pre-treatment soil indicated that the soil was acidic, medium in available P, K and Mg and low in available Ca status. Annual girth from the second year to the seventh year and girth increment during the period are presented in Table 1. During the second, third and fourth year of the trial, growth differences were not statistically significant. From the fifth year, difference in girth was prominent. During fifth year, fertilizer and lime treatments alone or in combinations were significantly superior to control (no-fertilizer and no-lime). Application of lime alone was also on par with the fertilizer alone or fertilizer with lime treatments indicating the beneficial effect of liming in these acid soils. During the seventh year, lime application at the 75 and 100 per cent LR along with fertilizer treatments was significantly superior to lime alone at the 100 per cent LR indicating the long-term beneficial effect of lime and fertilizer application. Liming improved the rhizosphere pH temporarily and improved the availability of nutrients and base status of the soil. Improvement in pH was temporary and this might have improved the availability of nutrients both native as well as supplied through the fertilizers which in turn favoured the growth of plants.

Table 1. **Effect of liming on growth of plants**

Treatment	Girth (cm)						Girth increment (cm)
	1999	2000	2001	2002	2003	2004	1999-2004
Control	7.2	12.9	18.4	23..3	28.4	35.9	28.7
Fertilizer alone	8.2	14.2	21.1	27.9	33.4	39.3	31.1
100% LR alone	7.9	14.7	20.6	27.6	32.3	38.2	30.3
25%LR + Fertilizer	8.1	14.5	21.4	28.2	34.3	39.0	30.9
50%LR + Fertilizer	8.4	14.7	22.3	28.7	34.3	40.2	31.8
75% LR + Fertilizer	8.3	14.3	21.0	27.9	34.3	40.5	32.2
100%LR + Fertilizer	8.4	14.6	21.3	27.8	35.1	41.1	32.7
SE	0.40	0.78	1.16	1.01	1.16	0.75	0.59
CD (P = 0.05)	NS	NS	NS	3.12	2.52	2.28	1.83

Table 2. **Effect of liming on the availability of nutrients**

Treatment	pH		OC (%)		Available nutrients (kg/ha)							
					P		K		Ca		Mg	
					Year of planting							
	2	5	2	5	2	5	2	5	2	5	2	5
Control	4.40	4.80	1.41	0.87	40.6	15.0	156.0	146.6	61.2	182.6	66.4	73.6
Fertilizer alone	4.49	5.00	1.19	0.94	21.4	16.6	222.0	290.6	70.0	324.0	39.2	156.4
100 %LR alone	4.57	5.10	1.53	0.81	21.4	16.2	221.4	253.4	300.0	686.0	54.2	45.4
25% LR + Fertilizer	4.52	4.90	1.22	0.98	23.4	55.2	240.0	323.4	139.2	346.0	40.6	59.2
50 % LR + Fertilizer	4.44	5.00	1.14	1.30	32.6	65.4	182.6	363.4	180.0	1014.6	38.6	84.0
75% LR + Fertilizer	4.57	5.10	1.29	0.98	40.0	45.6	220.0	383.4	169.6	734.0	48.8	89.8
100%LR + Fertilizer	4.61	5.30	1.09	0.84	28.0	42.0	240.0	370.0	174.8	1075.4	64.8	110.2
SE	0.10	0.09	0.15	0.11	8.6	8.6	24.8	49.2	25.2	45.6	1.40	12.0
CD (P = 0.05)	NS	NS	NS	NS	NS	25.8	74.4	148.2	78.0	140.6	NS	36.0

The effect of liming on the availability of nutrients in the surface soil during the second year and fifth year of experimentation is presented in Table 2. Parameters such as pH, organic carbon, available P and Mg were not influenced by the treatments. Available K values were significantly improved by the treatments. Even the lime alone treatment significantly improved the availability of K in the soil indicating the beneficial effect of liming in improving the availability of nutrients in the soil. Comparison of the second year and fifth year pH values is depicted in Figure 1. Three rounds of lime application *viz.* first year, third year and fifth year were followed during the five year period. Values of pH were not statistically significant. However, a gradation was noticed between the control and 100 per cent LR with fertilizer treatment. The values

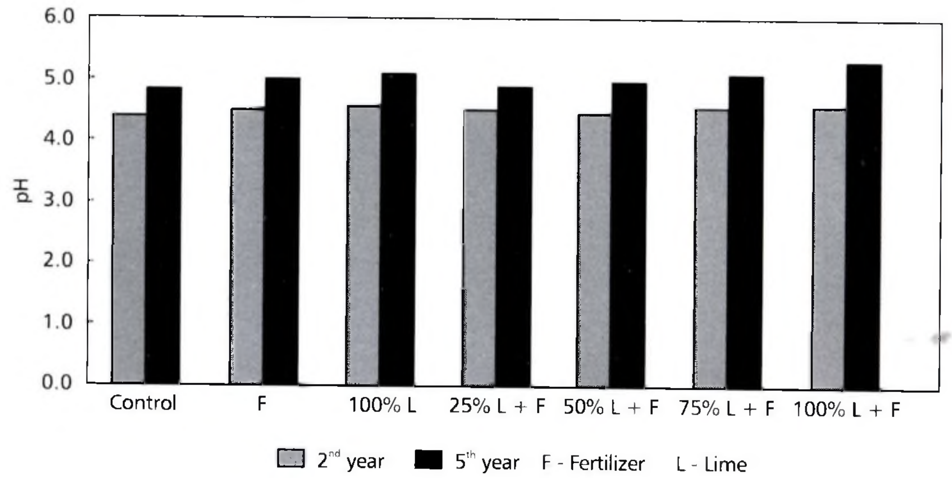

Fig.1. Changes in pH of the surface soil

ranged from 4.8 to 5.3 indicating that the pH of the soil changed from very strongly acidic to moderately acidic. During the fifth year, the pH and available nutrient status of the control plot also improved which might be due to the cultivation of the leguminous cover crop (*Pueraria phaseoloides*). When the canopy of rubber closes, the cover crop dies and large quantity of organic matter is added to the soil through the decomposing cover crop litter. Improvement in soil pH in *P. phaseoloides* established fields was reported by Philip *et al.* (2005). The content of K, Ca and Mg is higher in the *Pueraria* litter and the decomposition is comparatively faster than *Mucuna* (Philip *et al.*, 2005). In highly weathered soils liming is aimed to bring the soil pH to around 5.5 and reduce the exchangeable Al status and improve the base status of the soil (Kamprath, 1970). The organic matter status of the soil in the experimental site was in the medium range (Karthikakuttyamma *et al.*, 2000). The organic carbon content ranged from 0.81 to 1.30 per cent. In general, the organic matter status in the rubber growing soils is very high in the surface layers. Hence the buffering capacity of the soil is expected to be very high. In soils with very high buffering capacity, the pH changes through liming will be temporary and the pH will revert back to original in the long run. In this experiment, a pH change from 4.8 to 5.3 was achieved through three rounds of liming.

During the fifth year, the available P and K status of the soil were significantly improved by liming. Improved availability of nutrients, especially the availability of P and K through liming was reported by many workers (Haynes and Ludecke, 1981; Panda, 1999; and Sen, 2003). Application of lime alone significantly reduced the available Mg status of the soil indicating the antagonistic effect of excess supply of Ca on the availability of Mg in the soil. Similar results were reported by Grove *et al.* (1981), Edmeades *et al.* (1985) and Myers *et al.* (1988). The precipitation of Mg with newly formed aluminium hydroxide compounds may be the probable reason for the reduced availability of Mg.

Table 3. **Effect of liming on exchangeable nutrients**

Treatment	CEC (m.eq/100 g soil)		Exchangeable nutrients (m.eq/100 g soil)							
			Ca		Mg		K		Al	
	Year of planting									
	2	5	2	5	2	5	2	5	2	5
Control	4.60	4.60	0.16	0.66	0.17	0.18	0.45	0.28	0.69	0.63
Fertilizer alone	4.43	4.63	0.21	0.69	0.14	0.36	0.43	0.37	0.67	0.55
100 % LR alone	5.03	4.06	1.13	1.56	0.20	0.17	0.38	0.19	0.65	0.28
25% LR + Fertilizer	4.73	4.63	0.26	0.70	0.23	0.29	0.53	0.44	0.69	0.62
50 % LR + Fertilizer	4.47	4.93	0.29	0.71	0.17	0.22	0.32	0.42	0.69	0.54
75% LR + Fertilizer	4.57	4.83	0.78	0.78	0.14	0.21	0.34	0.45	0.83	0.39
100%LR + Fertilizer	5.57	5.23	0.96	2.14	0.25	0.26	0.40	0.44	0.84	0.32
SE	0.40	1.55	0.09	0.17	0.03	0.02	0.06	0.04	0.10	0.08
CD (P = 0.05)	NS	NS	0.29	0.37	0.10	0.05	NS	0.09	NS	0.17

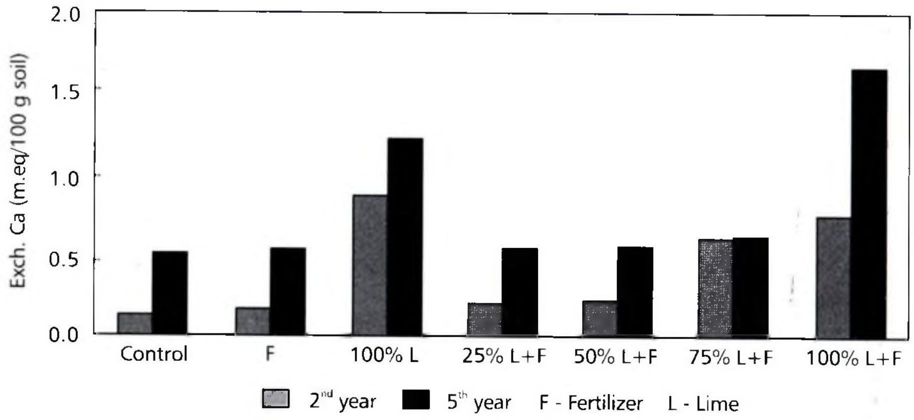

Fig. 2. Changes in exchangeable Ca in the surface soil

Effect of liming on the exchange properties of the soil during the second and fifth year of the experiment is presented in Table 3. Cation exchange capacity of the soil was positively influenced by lime application. However, the effect was not statistically significant in both the sampling periods. Liming significantly improved the exchangeable Ca status of the soil (Table 3, Fig. 2). Exchangeable Mg was reduced by the application of lime. In this experiment, the source of lime was powdered shell lime (calcium hydroxide) and excessive supply of Ca reduced the availability of Mg in the soil. Liming through dolomite (calcium magnesium carbonate) may be the best alternative, especially, for a crop like rubber where Mg is important and included in the fertilizer schedule in the immature phase. Exchangeable Al content of the soil sampled during the second year, *i.e.* with one round of liming, was not influenced by liming (Table 3, Fig. 3).

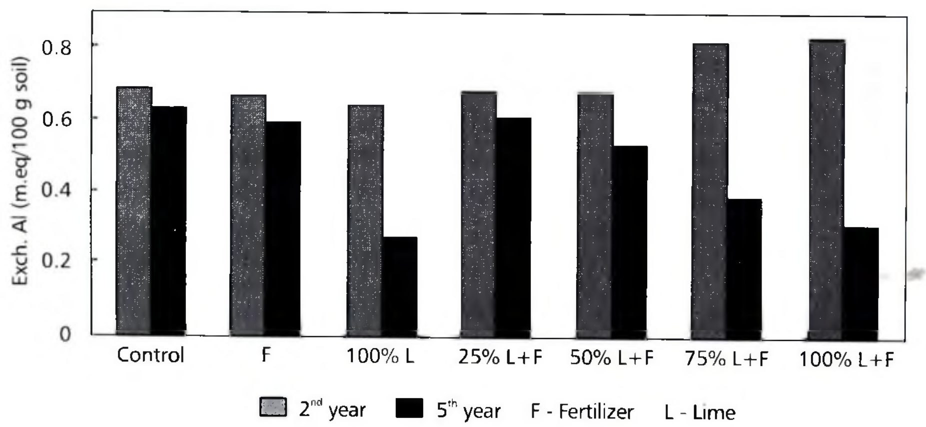

Fig. 3. Changes in exchangeable Al in the surface soil

During the fifth year, *i.e.* after three rounds of liming, the exchangeable Ca and K status of the soil were significantly improved (Table 3). The exchangeable Mg status of the soil was reduced by lime alone treatment. At the same time, lime and fertilizer treatments improved the exchangeable Mg status compared to the control but was slightly low compared to the fertilizer alone treatment. Exchangeable Al content in the soil was significantly reduced by lime alone or lime at 75 per cent or 100 per cent LR plus fertilizer treatments (Fig. 3). Studies have shown that liming to pH 5.5, particularly in highly weathered soils where exchangeable Al is neutralised, improves crop production (Evans and Kamprath, 1970; Reeve and Sumner, 1970).

Leaf nutrient concentration was assessed during fifth, sixth and seventh year of experimentation to study the effect of liming on the nutrient balance in the plant system. Application of lime increased the leaf Ca concentration and the effect was statistically significant during the seventh year of the experiment (Fig. 4).

Liming improved the growth of plants. Statistically significant positive effect on girth of plants was recorded from fifth year of experimentation. Growth of plants in lime alone or lime in combination with fertilizer treatments were found to be significantly superior to control plants. Lime alone treatment was found to be as good as fertilizer alone treatment during the fifth year indicating the beneficial effect of liming in these acid red ferruginous soils. During the seventh year, liming at 100 per cent LR in combination with fertilizer was significantly superior to lime alone application indicating the beneficial effect of liming in improving the availability of nutrients supplied through fertilizers in these acid soils. The pH of the soil changed from very strongly acidic to moderately acidic favouring the availability of native as

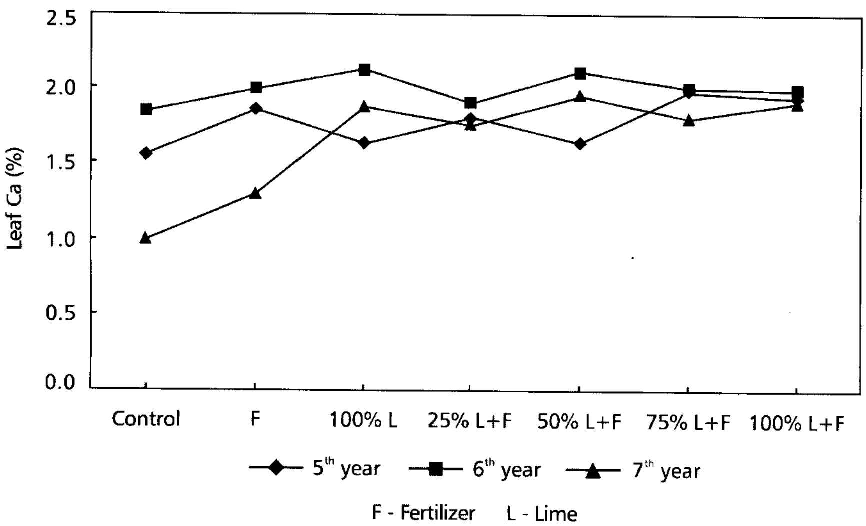

Fig. 4. Effect of liming on Ca concentration in the leaves

well as applied nutrients. During the fifth year, the available P and K status of the soil was significantly improved by liming. Lime alone application significantly reduced the available Mg status of the soil indicating antagonistic effect of excess supply of Ca on the availability of Mg in the soil. Liming significantly improved the exchangeable Ca status of the soil. Exchangeable Al content in the soil was significantly reduced by lime alone or lime at the 75 per cent LR or 100 per cent LR along with fertilizer treatments.

REFERENCES

Adams, E. (1981). Nutrient importance and constraints to plant growth in acid soils. *Journal of Plant Nutrition*, **4**: 81-88.

Adams, E. (1984). Crop response to liming in southern United States. In: *Soil Acidity and Liming* (Ed. E. Adams). Agronomy Monograph, 12, American Society of Agronomy, Madison, Wisconcin, pp. 355-357.

Edmeades, D.C. Wheeler, D. M. and Crouchley, G. (1985). Effect of liming on soil magnesium in some soils in New Zealand. *Communications in Soil Science and Plant Analysis*, **16**: 727-739.

Evans C.E. and Kamprath, C. J. (1970). Lime response as related to percent aluminium saturation, solution aluminium and organic matter content. *Soil Science Society of America Proceedings*, **34**: 893-896.

Grove, J. H., Sumner, M. E. and Syers, J. K. (1981). Effect of liming on exchangeable magnesium in variable surface charge soils. *Soil Science Society of America Journal*, **45**(3): 497-500.

Haynes, R. J. and Ludecke, T. E. (1981). Effect of lime and P application on concentration of available nutrients and on P, Al and Mn uptake by two pasture legumes in an acid soil. *Plant and Soil*, **62**: 117-128.

Jackson, M.L. (1958). *Soil Chemical Analysis*. Prentice Hall Private Ltd., New Delhi, 498p.

Kamprath, E. J. (1970). Exchangeable aluminium as criterion for liming leached mineral soil. *Soil Science Society of America Proceedings*, **24**: 252-254.

Karthikakuttyamma, M. (1997). *Effect of continuous cultivation of rubber* (Hevea brasiliensis) *on soil properties*. Ph.D. thesis, University of Kerala, Thiruvanathapuram, India, 176p.

Karthikakuttyamma, M., Joseph, M., and Nair, A. N. S. (2000). Soils and Nutrition. In: *Natural Rubber: Agromanagement and Crop Processing* (Eds. P.J. George and C. Kuruvilla Jacob), Rubber Research Institute of India, Kottayam, pp. 170-198.

Krishnakumar, A. K. (1989). *Soils under Hevea in India: A physical, chemical and minerological study with reference to soil moisture cation influence on yield of* Hevea brasiliensis. Ph.D Thesis, Indian Institute of Technology, Kharagpur, India.

Myers, J. A., McLean, E. O. and Bingham, J. M. (1988). Reduction in exchangeable magnesium with liming acid Ohio soils. *Soil Science Society of America Journal*, **52**: 131-136.

NBSS and LUP (1999). *Resource Soil Survey and Mapping of Rubber Growing Soils of Kerala and Tamil Nadu*. National Bureau of Soil Survey and Land Use Planning, Nagpur, 295p.

Panda, N. (1999). Problems and prospects of efficient use of fertilizers in acid soils of India. *Fertilizer News*, **43**(8): 39-50.

Philip, A., George, E.S., and Punnoose, K.I. (2005). Effect of *Pueraria phaseoloides* and *Mucuna bracteata* on the physico-chemical properties of soils of immature rubber plantations. *Natural Rubber Research*, **18**(1): 93- 100.

Piper, C.S. (1966). *Soil and Plant Analysis*. Hans Publishing House, Bombay, 368p.

Reeve N.G. and Sumner, M.E. (1970). Lime requirement of Natal Oxisols based on exchangeable aluminium. *Soil Science Society of America Proceedings*, **34**: 595-598.

Sanchez, P.A. (1976). *Properties and Management of Soils in the Tropics.* John Wiley and Sons, New York. 618p.

Sen, H.S. (2003). Problem soils in India and their management: Prospect and retrospect. *Journal of the Indian Society of Soil Science,* **51**(4): 388-408.

Shoemaker, H.E., McLean, E.O. and Pratt, P.I. (1961). Buffer method for determining lime requirement of soils with appreciable amounts of extractable Al. *Soil Science Society of America Proceedings,* **25**: 274-277.

Suresh, P.R., Karthikakuttyamma, M., Pothen, M. and Augusthy, A. (1994). Contribution of exchangeable Al to subsoil acidity in rubber growing tracts. *Proceedings of the Sixth Kerala Science Congress,* January, 1994, STEC, Thirvanathapuram, pp. 140-142.

Tisdale, S.L., Nelson, W.L., and Beaton, J.D. (1985). *Soil Fertility and Fertilizers.* Fourth Edition, Macmillian Publishing Company, New York, 754p.