Jl. Rubb. Res. Inst. Sri Lanka, (1995), 75(I), 13–30

EFFECT OF POTASSIUM ON GROWTH, YIELD AND MINERAL COMPOSITION OF YOUNG *HEVEA BRASILIENSIS*

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(Accepted 29 November 1994)

SUMMARY

The effect of potassium fertilizer on the performance of clone RRIC 100 series was studied by measuring growth, yield and determining the nutrient content in leaves in *Boralu, Agalawatta, Ratnapura, Homagama* (red yellow podzol) and *Parambe* (reddish brown latazol) series soils. Application of potassium at the rate of 33g/tree/year enhanced girthing but no further increase was observed with increasing potassium level. Among the different soil series, plants grown in *Parambe* series exhibited the highest rate of growth in the first year. Significant interaction between applied potassium and soil series on leaf K and Mg were observed. Potassium application increased the K/Mg, K/Ca and K/(Mg+Ca) ratios in the leaves.

INTRODUCTION

Potassium is one of the major essential element required in large quantities by *Hevea brasiliensis* along with nitrogen and phosphorous (Anon 1971). *Hevea* has shown varying responses to potassium at different locations. In certain soils of Sri Lanka application of potassium fertilizers enhanced growth while in other soils no significant response were indicated (Constable 1955, Jeewaratnam 1963 and 1970 and John 1967). It is also observed that soils which have low levels of potassium showed significant response to applied potassium (Weerasuriya 1987). Many workers have reported the existence of antoganisam between potassium and magnesium on leaf K and Mg content (Guha 1975, Agboola and Corey 1973, Yogaratnam *et al* 1984 and Weerasuriya 1987).

Recent findings by RRISL suggests that the new high yielding and vigorously growing clones such as RRIC 100 and RRIC 121 may need higher level of potassium to give the maximum rate of growth during the 1st year in K deficient soils. This paper discuss the effects of levels of potassium fertilizer on the performance of clone RRIC 100 growing during the 1st year of growth in five soil series.

EXPERIMENTAL

This experiment investigated the effects of three levels of potassium on growth, yield and uptake of nutrients of clone RRIC 100 grown in different soil series in pots. The treatments were tested in a complete randomized design and replicated four times. The levels of potassium was K-0 (no potassium) K-1 (33g of K plant/year) and K-2 (66g of K plant/year) and soil series were *Boralu, Agalawatta, Ratnapura, Homagama* (red yellow podzolic - Quartizitic) and *Parambe* (reddish brown latazol - Micaceous) (Silva 1971).

Treatment fertilizer was applied in the form of muriate of potash and uniform application of 33g of N 17g of P and 11g of Mg per plant per year were applied in the form of urea, rock phosphate and kieserite respectively. The plants were grown in large barrels (50 cm diameter and 100 cm in length). Barrels were filled with soils of different soil series according to the experimental design and two brown budded stumps were planted. Six weeks after planting one plant was removed and a healthy plant was retained. Commencing from 2 weeks, fertilizer were applied in four split applications.

Pre-treatment soil analyses were done. Diameter and height of the plants, were made at 3 months intervals.

At the end of the experimental period of 12 months, all the plants were uprooted and each were separated to leaves, petioles, stems and roots. Fresh and dry weights of these components were done. Leaf area measurement were also made. These data were used for growth analysis (Roderick Hunt 1978).

Assessment of latex production (yield) by microtapping technique (Waidyanatha and Fernando 1972) was done at 12 months. Leaf samples were collected at 6 months intervals for chemical analysis. Leaf N and P were determined colorimetrically and K was determined by flame photometry. Ca, Mg and Mn were determined by atomic absorption spectrophotometry (Manual RRIM 1971b).

RESULTS

The statistical significance is indicated by the standard error of the differences (SED) and in all the tables *, ** and *** denote that treatments are significantly different from the control in levels of applied K at P = 0.05, 0.01 and 0.001 levels, respectively. Duncan's New Multiple Range Test was used to compare the effect of soils series and all the means followed by a common letter are not significantly different at 5% level.

Plant Diameter

Application of potassium at K1 level significantly increased plant diameter at the end of 6, 9 ($P<0.01$) and 12 months ($P<0.001$) (Fig. 1) and there was no further increase with application at K2 level.

Measurements made at 6,9 and 12 months indicate that plants grown in Parambe series soil had the highest ($P<0.001$ at 6 months and $P<0.001$ at 9 and 12 months) plant diameter (Fig. 2) and the lowest was recorded in Ratnapura series.

Plant Height

Significant increase ($P<0.001$) in plant height was observed with applied K at level 1 (Fig. 3). But no further increase was obtained when K was applied at K2 level.

From 6 months onwards, significant differences ($P<0.001$ at 6 and 12 months and $P<0.001$ at 9 months) were also seen between soil series on plant height (Fig. 4). The lowest was recorded in Ratnapura series and the Parambe series showed the highest.

Dry weights of shoot, root and total

Application of potassium at K1 level significantly increased ($P<0.001$) on shoot and total dry weights (Table 1). With regard to the effect of soil series shoot and root dry weights showed the highest ($P<0.05$) value in Parambe series (Fig. 5).

Table 1. *Effect of levels of K on shoot dry weight and total dry weight at the end of 12 months*

Level	Shoot Dry Weight (g)	Total dry weight(g)
K_0	961.78	1934.89
K_1	1821.96***	3094.56***
K_2	1474.61*	2752.63*
SED	189.03	275.09

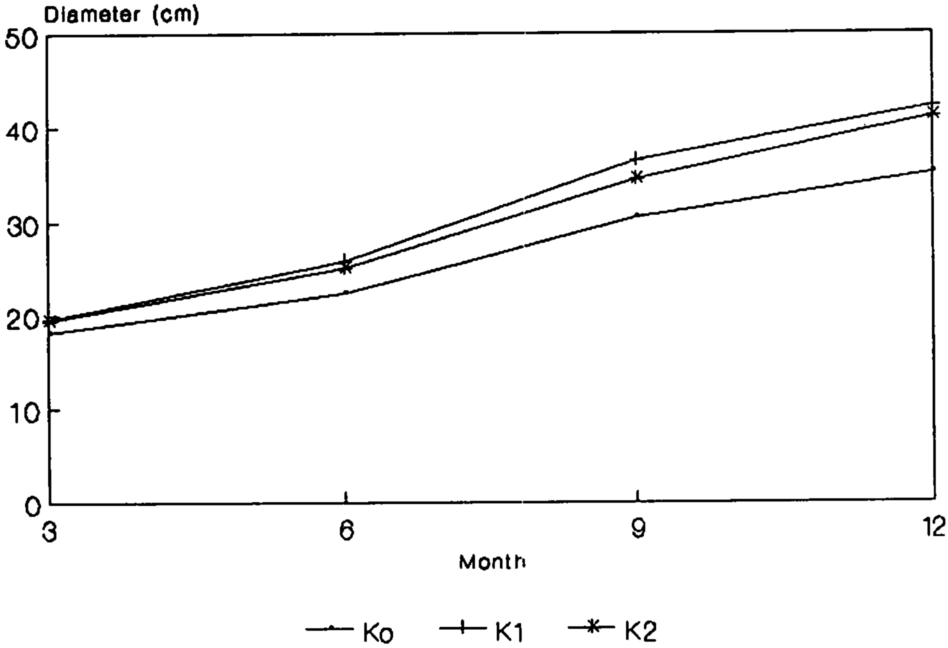
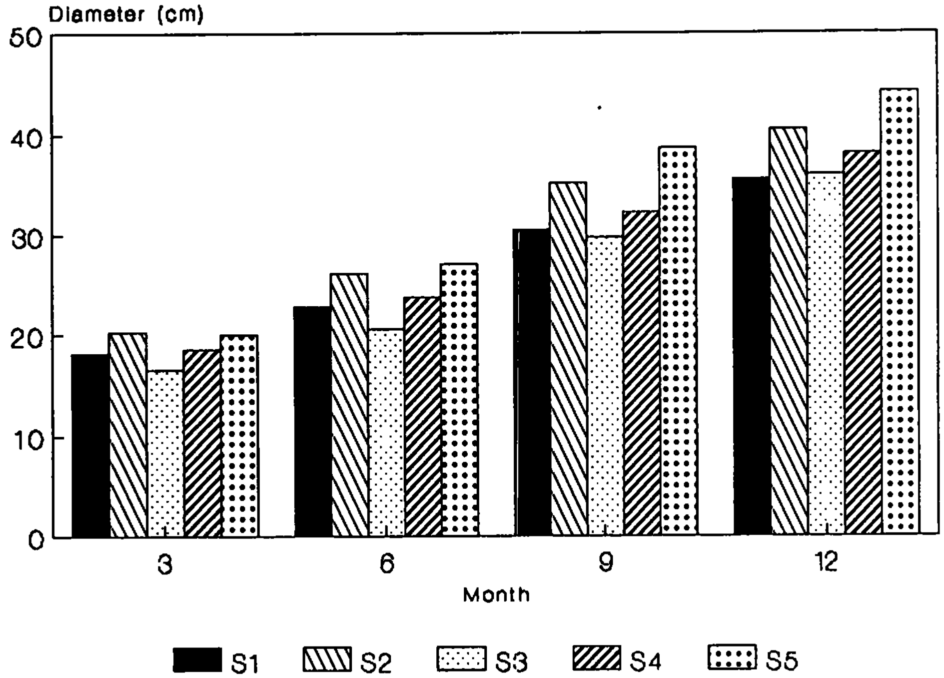


Fig. 1 Effect of levels of applied K on plant diameter



S1 – Boralu S2 – Agalawatta S3 – Ratnapura
S4 – Homagama S5 – Parambe

Fig. 2 Plant diameter in different soil series

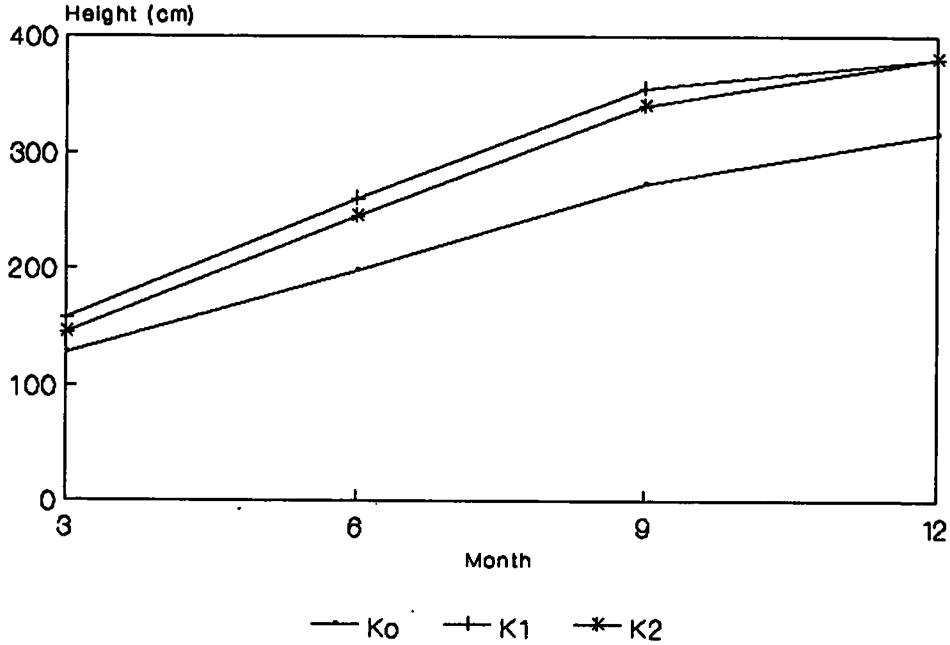
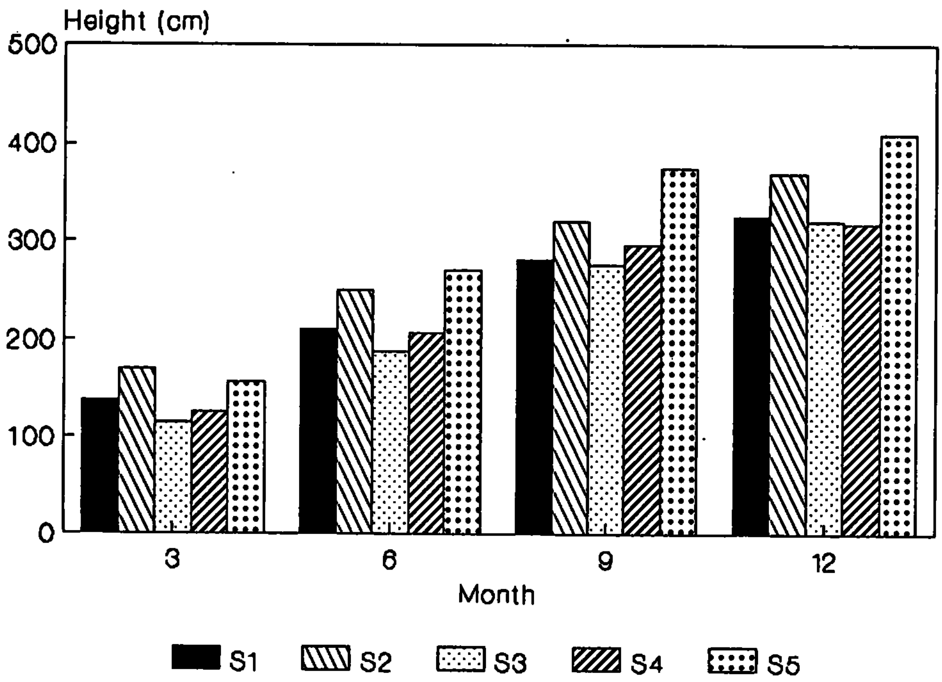


Fig. 3 Effect of levels of applied K on plant height



S1 – Boralu S2 – Agalawatta S3 – Ratnapura
S4 – Homagama S5 – Parambe

Fig. 4 Plant height in different soil series

Leaf area

Significant increase ($P<0.05$) in leaf area was observed with K at level 1 but there was a tendency to the leaf area to be reduced when K was at K2 level (Table 2).

Table 2. *Effect of levels of K on leaf area at the end of 12 months*

Level	Leaf area (m_2)
K_0	2.18
K_1	3.16*
K_2	2.62
SED	0.33

Relative growth rate

Relative growth rate was significantly increased ($P<0.001$) with application of K at K1 level, but no additional effect when increased to K2 level (Table 3)

Table 3. *Effect of levels of K on relative growth rate and leaf weight ratio*

Level	Relative growth rate (gg^{-1} wk^{-1})	Leaf weight ratio
K_0	0.09	0.11
K_1	0.10***	0.08*
K_2	0.10***	0.09*
SED	0.002	0.01

Leaf weight ratio

Leaf weight ratio also showed a significant reduction ($P<0.05$) with application of K at K1 level. But no further reduction was recorded when K was increased to K2 level (Table 3).

Yield

Latex production by micro tapping

Application of K at level 2 significantly increased ($P<0.01$) micro tapped yield on all the soil series (Table 4). There were also significant differences ($P<0.05$) between soil series on yield (Table 5). Where plants grown in Ratnapura series recorded the lowest yield in comparison with plants in Parambe, Boralu and Agalawatta series.

Table 4. *Effect of levels of K on latex production*

Level	Latex production (g)
K0	0.07
K1	0.09*
K2	0.10*
S.E.D.	0.01

Table 5. *Latex production in different soil series*

Soil series	Latex production (g)
Boralu	0.09A
Agalawatta	0.09A
Ratnapura	0.07B
Homagama	0.09AB
Parambe	0.10A
S.E.D.	0.01

Leaf Nutrients

Potassium

There was an interaction between applied K and soil series on leaf K content at 6 months (Fig.6). Application of K at K1 level significantly increased the leaf K content in Boralu ($P<0.05$), Agalawatta ($P<0.01$) and Homagama ($P<0.01$) series. When K was increased to K2 level, there was significant increase in the leaf K content in Boralu series ($P<0.01$) and a reduction in Agalawatta series ($P<0.05$). But in Homagama series the differences between K1 and K2 levels of applied K was not significant. In Ratnapura series significant increases ($P<0.05$) on leaf K content were obtained only at K2 level. Leaf K content was however not influenced by the application of K in plants grown in the Parambẹ series soils.

At 12 months, a significant interaction was observed between applied K and soil series on leaf K content (Fig. 7). Application of K at K1 level, significantly increased ($P<0.01$) the leaf K content in Boralu, Agalawatta and Homagama series. Further increase in potassium to K2 level, increased the leaf K content significantly ($P<0.05$) only in Boralu series. But plants in Ratnapura series recorded a significant positive response ($P<0.05$) when K was at K2 level. Plants in Parambe series did not show any effect due to the treatments.

Magnesium

Significant reduction ($P<0.001$) in leaf Mg content was observed with application of K at k1 level at 6 months after planting (Table 6). No further significant differences were seen between K1 and K2 levels of applied K.

Table 6. *Effect of levels of K on leaf Mg content at 6 months*

Levels	Leaf Mg content
K0	0.3090
K1	0.1874***
K2	0.1672***
S.E.D.	0.0281

At 12 months there was a significant interaction ($P<0.05$) between applied K and soil series on leaf Mg contents (Fig. 8). Where plants grown in Boralu, Agalawatta and Homagama series showed significant reduction in leaf Mg contents due to applied K at K1 level, and no further significant differences were seen when K was increased to K2 level. But plants in Ratnapura series showed the similar effect with applied K only at K2 level.

Calcium

Leaf Ca content showed significant differences ($P<0.05$) between soil series at 6 months (Table 7). Where plants grown in Parambe series recorded the highest leaf Ca content, although at 12 months leaf Ca content was not affected by treatments.

Manganese

At the end of 6 and 12 months leaf Mn content was significantly influenced ($P<0.01$) by soil series (Table 7) irrespective of the application of potassium. In assessments made at 6 and 12 months, plants grown in Parambe series recorded the highest leaf Mn content.

Table 7. *Leaf Ca and Mn contents in different soil series*

Soil series	Leaf Ca Content(%)	Leaf Mn content (ppm)	
	6 months	6 months	12 months
Boralu	0.77A	29.50A	56.25C
Agalawatta	0.81A	57.04B	90.42B
Ratnapura	0.94AB	62.19B	129.38A
Homagama	0.82A	74.75B	126.59A
Parambe	1.18B	80.75B	134.50A
S.E.D.	0.02	12.75	12.62

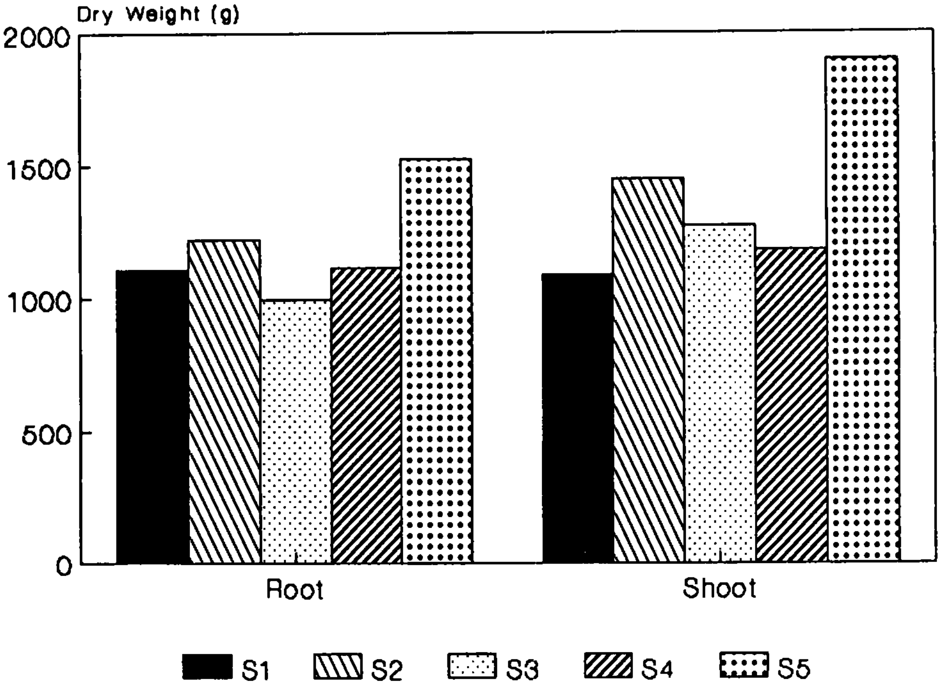
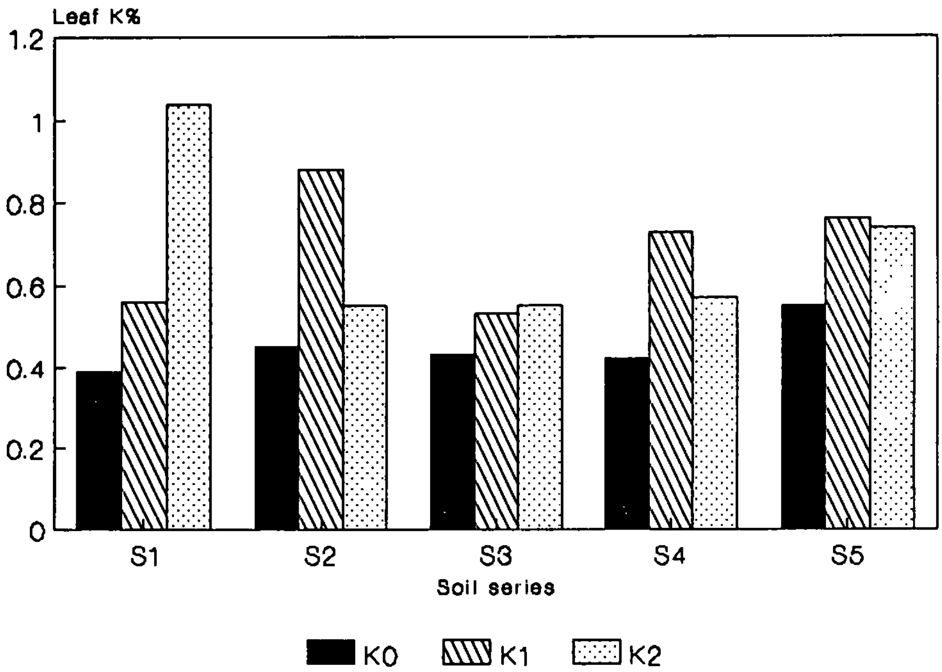
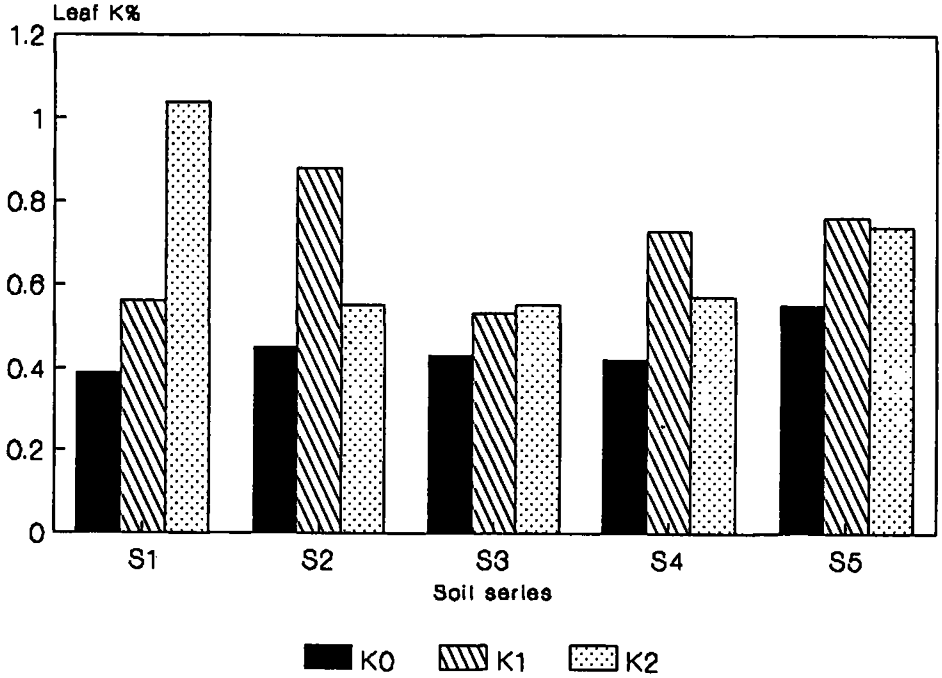


Fig. 5 Root and shoot dry weights in different soil series



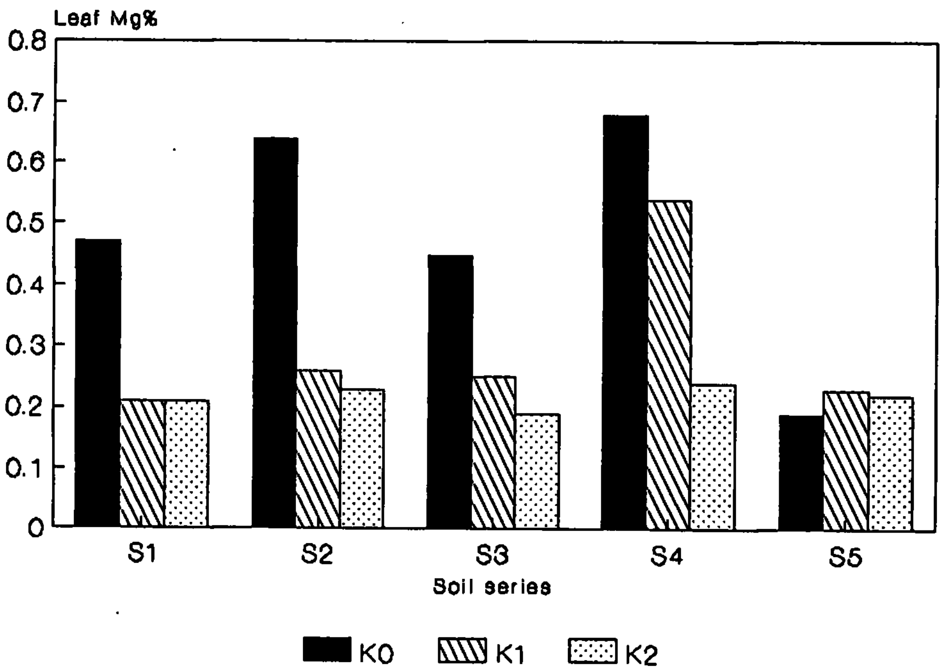
S1 – Boralu S2 – Agalawatta S3 – Ratnapura
S4 – Homagama S5 – Parambe SED = 0.1058

Fig. 6 Effect of levels of applied K on leaf K content at 6 months



SED = 0.101

Fig. 7 Effect of levels of applied K on leaf K content at 12 months



S1 – Boralu　　S2 – Agalawatta　　S3 – Ratnapura
S4 – Homagama　　S5 – Parambe　　SED = 0.0994

Fig. 8 Effect of levels of applied K on leaf Mg content at 12 months

Leaf Nutrient Ratios

K/Mg

At the end of 6 and 12 months, leaf K/Mg ratio was significantly increased ($P<0.001$) with application of potassium at K1 level and no further increase with application at K2 level (Table 8).

K/Ca

Leaf K/Ca ratio was significantly increased with applied K at K1 level ($P<0.05$) at 6 months, and K2 level ($P<0.02$) at 12 months (Table 8).

K/Ca+Mg

At the end of 6 months, application of K at K1 level significantly increased ($P<0.01$) leaf K/Ca+Mg ratio in all the soils (Table 8). At 12 months similar effects were obtained with applied K at K2 level ($P<0.001$).

Table 8. *Effect of levels of applied K on leaf K/Mg, K/Ca and K/(Ca+Mg) ratios*

Level	K/Mg		K/Ca		K/(Ca+Mg)	
	6 months	12 months	6 months	12 months	6 months	12 months
K0	1.61	1.56	0.39	0.36	0.51	0.53
K1	4.85***	3.21***	0.85**	0.67*	1.05**	0.88
K2	6.12***	3.82***	0.80**	0.95***	0.95**	1.36***
SED	1.01	1.04	0.15	0.14	0.20	0.23

DISCUSSION

The soil series used in this study were *Boralu, Agalawatta, Homagama, Ratnapura* and *Parambe*. The pre treatment exchangeable K value in Parambe series was 0.53 me/100g of soil and exchangeable K in Agalawatta and Homagama series were o.05 me/100g of soil. The exchangeable K values of *Boralu* and *Ratnapura* series were 0.04 me/100g soil. The value of 0.04 me/100g soil of exchangeable was considered to deficient for normal growth of rubber plants (Yogaratnam *et al* 1984).

The results obtained from this experiment indicate that plants grown in Parambe soil series showed significantly higher girthing at the end of 12 months. The absence of any interaction between soil series and potassium on growth during the first 12 months suggest that under the conditions of this experiment the K requirement of immature rubber is not likely to change when grown in different soil series at least in the first year of growth.

Yogaratnam and Weerasuriya (1984) and Weerasuriya (1987) reported significantly higher responses to applied K in potassium deficient soils such as *Boralu* and *Homagama*. Similar results were reported in Malaysia (RRIM 1987) and India (Krishnakumar and Potty 1989). These workers however did not compare the effects of applied K with soils that are derived from parent materials rich in K such as mica containing parent materials.

Rubber soils in Sri Lanka were classified by Silva (1970) according to their parent material and reported that Parambe series soil derived from micaceous parent materials is rich in K. Based on this the fertilizer recommendation for rubber in Sri Lanka was revised and fertilizer mixture low in potassium was recommended for *Parambe* series soils while for all other soils, fertilizer mixtures comparatively high in potassium have been recommended.

John (1967) reported that potassium status with particular reference to water soluble K, exchangeable K, difficulty exchangeable K and total K varied between soil series. Therefore one would have expected higher responses from soils low in these soil parameters. On the other hand, according to the soil classification of Moorman and Panabokke (1961) one would not have expected any differences in plant response in terms of growth due to soil series as all these series except Parambe falls under the great soil group of red yellow podzolic.

It now appears that based on the finding of this study, fertilizer recommendation for rubber in Sri Lanka may have to be revised again. It therefore appears possible to apply the same fertilizer mixture to all the soil series at least in the first year there by saving on the extra K fertilizer that is currently applied to all the soil series except Parambe. The low K mixture (15:15:7) which is currently recommended to only the K rich Parambe series soils can be recommended to all the other soils, thus effecting some saving on the potassium fertilizer bills.

It is possible that the level of K in the Parambe soils had only a minor role to play with regard to the enhanced growth of immature plants seen in this experiment. But some of the physico-chemical characteristics of Parambe soils such as higher CEC, organic carbon etc, may have had interacting effects on growth. Yogaratnam et.al (1984) reported higher CEC and organic carbon content in Parambe series soil in comparison with the other soil series. Pre-treatment soil analytical data of this study also indicated higher CEC value of 10.64 me/100g and organic carbon content of 2.12% in Parambe soil.

Although in a comparable previous study, Weerasuriya (1987) reported that the potassium requirement of the newly developed RRIC clones are likely to vary at least in the first year, this effect was not seen in the present study possibly due to the difference in the root stock used in this study. The root stock used in this study was PB 86. It is known that in clonal materials, root stock has an influence on the performance of the scion in apple (Yogaratnam 1975) and in rubber (Samaranayake 1990). It may be that with PB 86 root stock, soil K concentration in the range of 0.05 me/100g soil is sufficient for normal growth of immature rubber plants during the first 12 months. In such a situation potassium fertilizer application in the first year may not be that critical unless this has some residual effects on the growth in the following years. This aspect cannot be considered in this study as this experiment was terminated at the end of 12 months.

The absence of response to K when applied at K2 level indicates that the crop's requirements of K is not as high as K2 level under the condition of the experiment (Yogaratnam *et al* 1984; Weerasuriya 1987; Krishnakumar and Potty 1989 and RRIM 1986). It is also possible that when K is applied in higher doses, part of it gets lost by leaching out of the root zone. High mobility and leaching losses of K from soils are well known (Pushparajah *et al* 1977).

Most of the other parameters, assessed in this study such as plant height, total dry weight, shoot dry weight, root dry weight and leaf dry weight also lend support to the results obtained with regard to effect of treatments on girthing suggesting an overall effect of treatments on the performance of young immature plants.

Yield of latex measured by micro-tapping technique, was significantly higher when potassium was applied at K1 level and no further increase was observed when K was increased to K2 level. It must however, be emphasized that although this cannot be considered as a very reliable technique for predicting yield potential in rubber (Paardekooper 1956) yet it could be used for comparative assessment of experimental treatments at least during first few years of growth. Nevertheless the influence of potassium on latex stability, leading to improvements in yield are generally accepted (Pushparajah 1969).

The leaf analysis data provides abundant evidence of uptake of potassium and magnesium as reported by other workers (Pushparajah 1969; Guha 1975; Yogaratnam and Silva 1977 and Yogaratnam and de Mel 1986). Efficiency of potassium and magnesium uptake by immature plants appears to have been influenced by the level of applied K and by the pre-treatment K and Mg content of the soil.

Significant interaction between soil series and levels of applied K suggests that K uptake by immature plants as indicated in this case by leaf K contents is influenced by the soil series where the plants are grown. As discussed earlier, differences in the K level of the rubber soils are known. One would therefore expect a higher K uptake from soils low in K such as the Boralu and Ratnapura series after fertilizer application. This uptake however need not be related to increases in growth or yield.

Several known nutrient antagonisms in *Hevea* have also been recorded in this study. The most common and important antagonism is between applied K and Mg on leaf K and Mg contents (Agboola and Corey 1973, Terman *et al* 1975, Weerasuriya 1987). Significant interaction between soil series and levels of applied potassium suggests that in Boralu, Agalawatta, Homagama and Ratnapura series soils, caution should be exercised when applying higher levels of K as this would lead to reduction in the leaf Mg content leading to the occurrence of Mg deficiency symptoms, confirming previous reports on this aspect on rubber (Yogaratnam and Weerasuriya 1984) and on tea (Krishnapillai 1991). Although one would have expected a more severe reduction in Mg content in Parambe soil with application of K fertilizers, this did not happen possibly due to the higher soil Mg content in the soil used for this study as indicated by the pre-treatment analysis.

Higher level of applied K was found to decrease the Mg content of leaf as reported by Yogaratnam and Perera (1981) and (Yogaratnam and Weerasuriya 1984). It is therefore important to maintain a well balanced K/Mg ratio in the leaf in order to avoid deficiency symptoms and for healthy growth of immature plants. This can be easily achieved by monitoring the level of applied K fertilizer.

Potassium application, though it has not affected the Ca content of the leaf significantly, has altered the K/Ca and K/Ca+Mg ratios in the leaf. It is generally believed that plants maintain the sum of cations such as K, Ca, Mg and Na fairly at a constant level (Ologunde and Sorensen, 1982). It is therefore important to maintain the K content of leaf at optimum level to avoid excessive accumulation of Mg and Ca.

The characteristic visual symptoms of potassium and potassium induced magnesium deficiency were observed at the early stages of the experiment in which K containing fertilizer was not applied and applied respectively. However significant responses were observed in terms of K and Mg contents of the leaves but these responses were not directly related to either growth or yield of latex by Micro tapping.

It is possible that there is a long time lag between occurrence of visual deficiency symptoms and adverse effects on either growth or production of latex in a perennial tree crop like rubber. More over it is well known that leaf nutrient status can only provide a enough indication of the nutritional status of the rubber tree. It can however be used as a sensitive indicator of the changes in nutrient status of trees caused by fertilizer application.

It should however be appreciated that the recommendation suggested in this study would apply only to the conditions under which this experiment were done. The different soil series considered in this study were used only for pot experiments lasting for a period of 12 months. The residual effects, leaching losses, soil microbial activity under normal field conditions, climatic factor *etc* were not considered in this study.

Therefore in order to make general recommendations additional investigations will have to be carried out taking all these aspects into consideration. These investigations will have to be therefore extended until the end of the immature period in order to obtain more meaningful results from the point of view of commercial plantation practices.

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(Received 4 August 1994)