EFFECT OF POTASSIUM AND MAGNESIUM ON GROWTH OF YOUNG HEVEA BRASILIENSIS

By

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SUMMARY

The effects of potassium and magnesium fertilisers on growth of young Hevea brasiliensis were studied using clones PB 86, RRIC 100, RRIC 103 and RRIC 121 with the objective of determining the requirement of these elements during the early phase of establishment of these clones. Three commercial fertilisers were evaluated as sources of magnesium.

Potassium requirement of clone PB 86 during the first year was found to be approsimately 33g K/plant/year. It was found that clones.RRIC 100 and RRIC 121 needed higher amount of K than PB 86 for normal growth. Potassium application caused an overall reduction in growth of clone RRIC 103 where the soil K level was 0.07me./100g suggesting that this level is adequate for this clone during its first year of growth.

Total dry weight was significantly increased when Mg application was increased from 11 to 22g/plant/year in clone RRIC 103 but such effects were not seen in clones PB 86, RRIC 100 and RRIC 121.

INTRODUCTION

It is known that the response to applied potassium and magnesium depends on the amounts of nutrients available in the soil (Constable and Hodnett, 1953; Akhurst, 1937; Jeevaratnam, 1963 and 1970; Ananth et al, 1966; Yogaratnam et al, 1984; Bolle Jones, 1954c; Rhines et at 1952). Suppressive effects on growth due to high levels of potassium or magnesium in the soil were also observed by many workers. (Fairfield Smith 1950, Constable and Hodnett, 1953; Bolle Jones, 1954 a; Punnose et at, 1975.)

Interactions on growth between potassium and magnesium have also been documented (Bolle Jones, 1954c and Yogaratnam et at 1984). In general potassium fertilisers increase growth, but the best responses are observed when combined with nitrogen (Owen et al, 1957; Shorrocks, 1960; Watson and Narayan, 1965; John, 1967; Pushparajah, 1969 and 1977; Von Vexkull, 1985). Application of potassium has also been found to increase dry matter production in seedlings; but at very high levels, dry matter yields decreased (Bolle Jones, 1954a; Lau, 1979). Large amount of magnesium is required during the early stages of growth than during the mature stage (Bolle Jones, 1954c).

This study was undertaken to reexamine and further acertain and quantity the potassium and magnesium needs of cultivated rubber Hevea brasiliensis. These two nutrients were chosen for this study as several cases of potassium and magnesium deficiencies have been reported in the recent past from rubber plantations in Sri Lanka. Since virtually no work has been done on the nutrient requirements of recently developed RRIC 100 series clones, three of these clones were included in this study. For the purpose of comparision the Malyasian clone PB 86 which is currently grown in about 75% of the area under rubber in Sri Lanka was also included.

EXPERIMENTAL

The effects of three levels of K and two forms of N and Mg fertilisers on growth of two clones PB 86 and RRIC 100 were studied in 3 replicates in experiment 1 in pots. The treatments included were: 0,33 and 66g of K per year, 11g of Mg in the form of Kieserite and Dolomite and 33g of N in the form of Urea and Sulphate of Ammonia. Phosphate was uniformly applied at the rate of 17g of P per plant per year.

In experiment 2 the effects of three levels of K viz 0,33 and 66g/yr. of K and three levels of Mg viz. 0,11 and 22g/yr of Mg on growth of four RRIC clones, PB 86, RRIC 100, RRIC 103 and RRIC 121 were studied in pots. N and P were added uniformly at the rate of 33 and 17g/yr respectively.

In both pot experiments empty barrels with both lids removed were buried in the soil leaving four inch rim above soil. Each barrel was filled with soil of *Homagama series* (red yellow podzol – quartzitic) (Silva 1971).

Two budded plants were planted into each barrel according to the design. All fertilisers were given in four split appliactions commencing, two weeks after planting. Application of Mg fertilisers were separated by atleast one month from application of nitrogen fertilisers to avoid the risk of loss of ammonia when Urea and Dolomite are mixed.

All plants were watered during dry period and the barrels were kept weed free throughout the experiment. Benlate (a systemic fungicide) was sprayed regularly to keep the plants disease free.

Assessments of growth were made at 3 – monthly intervals by measuring plant height from bud union and plant girth at 15 cm above the bud union. After 12 months, each plant was separated into components such as stems, leaves, petioles and roots and their fresh weights were recorded. For dry weights the plant components were dried at 80°C in an oven for 48 hours. Leaf area measurements were also made using a portable type leaf area meter. Relative Growth Rates were calculated using these data (Roderick Hunt, 1978).

In the field experiment 3, done on *Boralu Series* (red yellow podzol – lateritic) soil the effects of 3 sources of Mg namely, Commercial Epsom Salt, Kieserite and Dolomite at three levels (0,22 and 22g in first year and 0,15 and 30g in second year) and 3 levels of K applied as muriate of potash (0, 33 and 66g in first year and 0, 66 and 132g in second year) were studied in a split plot design with two replicates where the forms of Mg were in the main plot and factorial combinations of K and Mg were in sub plots. Girth measurements were made at 3-monthly intervals from a point 30 cm above the bud union for a period of 24 months.

RESULTS

Plant Diameter

In experiment 1, significant interactions were recorded between levels of applied K and clones on plant diameter measured at 3, 6, 9 and 12 months after planting ($P < 0.001$ for measurements made at 3, 6 and 9 months and $P < 0.01$ at 12 months) (fig. 1). It appears that the K requirement of Hevea varies between clones and that the K requirement of PB 86 is approximately K1 level where as that of RRIC 100 is higher than Kl level of applied potassium.

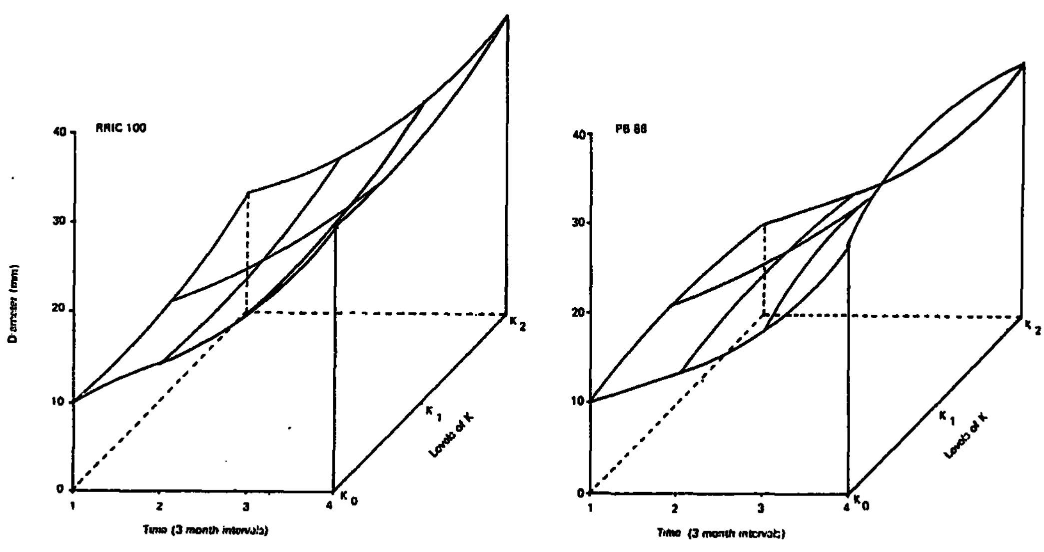

Fig 1 Effect levels of applied K on plant diameter of clones RRIC 100 AND PB 86

Application of Mg in the form of Kieserite significantly increased ($P < 0.05$) stem diameter at 9 and 12 months (table 1). But Dolomite application had no effect on stem diameter.

Table 1. Effect of sources of applied Mg. on stem diameter.

Source of Mg	Plant Diameter (mm)	
	1st assessment	2nd assessment
Nil Mg	19.2	29.5
Kieserite	21.2*	32.1*
Dolomite	20.4	30.0
SED	1.3	1.8

Plant diameter in experiment 3 was significantly increased ($P < 0.001$) by the application of K. This effect was uniform through out the study period as indicated by measurements made at 14, 18 and 22 months ($P < 0.001$). All assessments showed a non linear asymptotic regression type of response to K with K_1 being the optimum level (fig. 2).

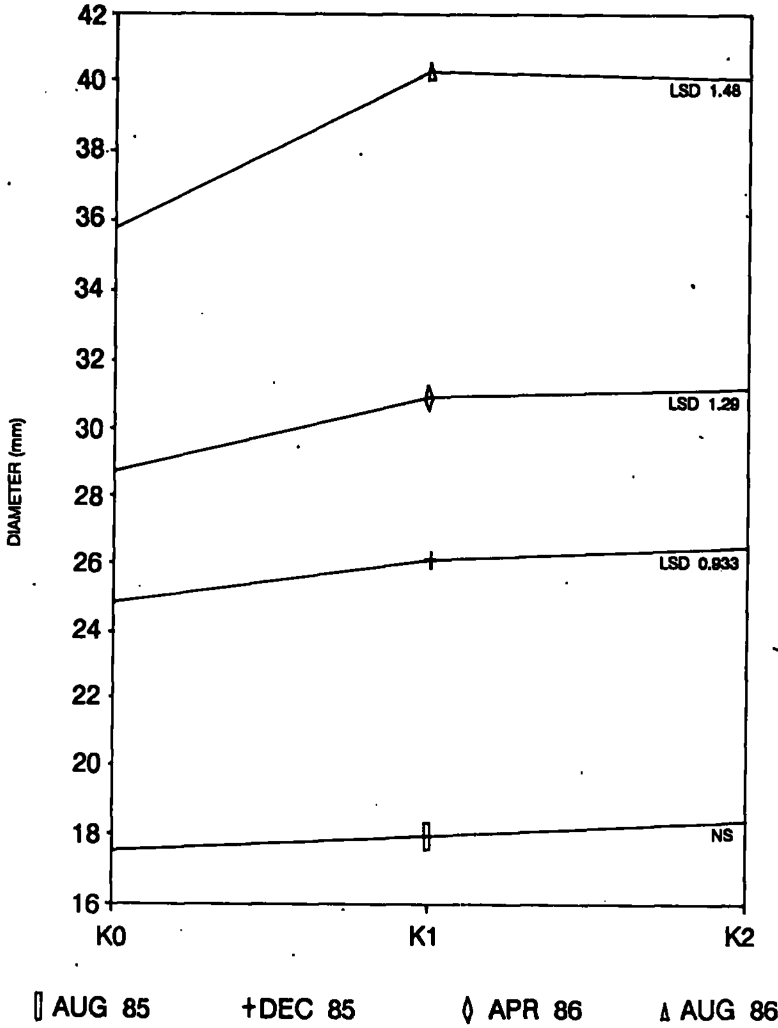

Fig. 2 Response in plant diameter to levels of applied K with age

The effect of K was not influenced by either of the sources of Mg applied viz. Commercial Epsom Salt, Kieserite or Dolomite.

Magnesium application showed a steady tendency in increaseing girthing of plants at the early stage and this effect first became significant at 14 months (table 2) and similar tendenc ies were observed there after. This effect of Mg application was however not influenced by the sources of Mg applied.

Table 2. *Effect of applied Mg on stem diameter*

Level of Mg	Steam diameter (mm) Aug 1985	Dec 1985	Apr 1986	Aug 1986
Mgo	17.82	25.44	30.05	38.16
Mg 1	17.66	25.66	30.27	38.55
Mg 2	18.55	26.55*	30.88*	39.66*
SED	0.388	0.452	0.625	0.721

Plant Height

In experiment 1, there was a significant interaction ($P < 0.05$) between sources of Mg and clones on plant height where application of Dolomite showed a retarding effect in RRIC 100 (fig. 3) at 3 months. PB 86 was not significantly affected by application of either Kieseri te or Dolomite although a slight increase was observed.

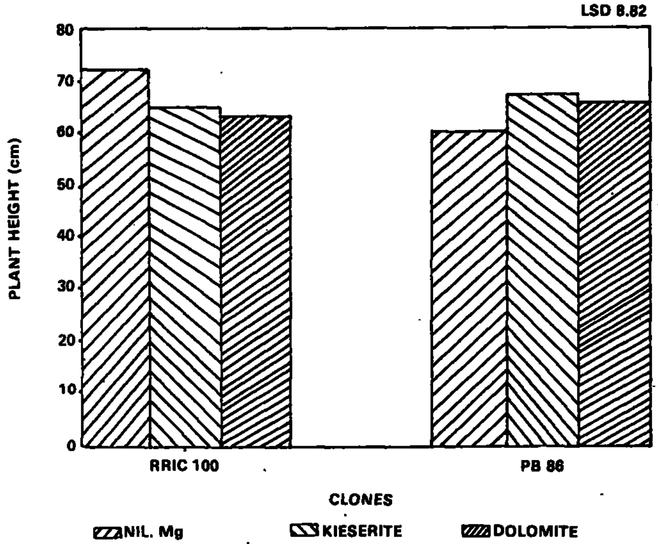

Fig. 3. Effect of applied sources of Mg on plant height of clones, RRIC 100 and PB 86.

Measurements made at 6 months showed a significant increase in plant height with the application of K at K2 level ($P < 0.05$) (table 30). In the assessments made at 9 and 12 months however there were significant interactions between applied K and clones ($P < 0.001$ at 9 months and $P < 0.001$ at 12 months (fig 4). Plant height of RRIC 100 was significantly increased with the application of K at K1 and K2 levels at 9 and 12 months, the increase in height at 9 months with application at K2 level was significantly higher than that with K1 level. This effect was however not significant at 12 months. PB 86 on the other hand showed quadratic effects at the end of 9 and 12 months. Application of K at K1 level significantly ($P < 0.001$) increased plant height at both assessments, but when K was increased to K2 level a significant reduction in plant height was observed in comparison with K1 level, at 9 ($p < 0.001$) and 12 ($P < 0.01$) months.

Table 3. *Effect of levels of applied K on plant height. (6 months after treatments).*

Level of K	Plant height (cm)
KO	99.63
K1	113.97
K2	123.57*
SED	9.55

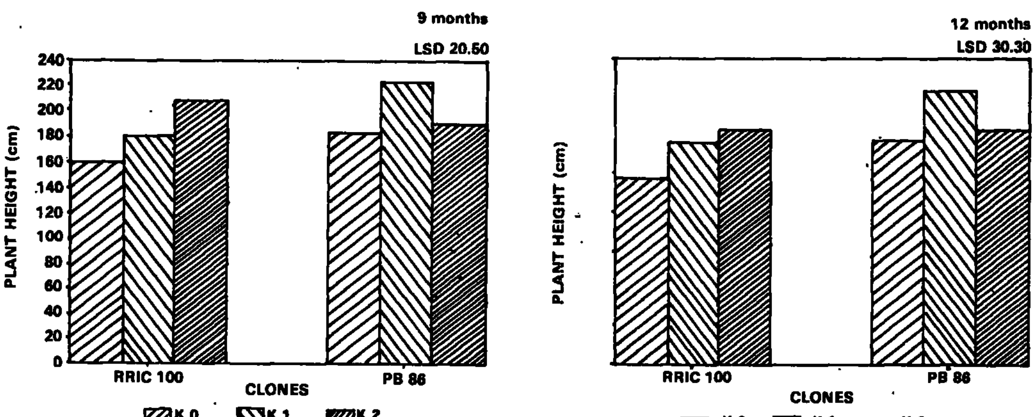

Fig. 4. Effect of levels of applied K on plant height on clones RRIC 100 to PB 86.

Significant interactions were also recorded between applied K and clones ($P < 0.05$) on plant height in experiment 2 at 6, 9 and 12 months after planting (fig 5). Clone PB 86 showed a tendency to increase height with K1 level which was significant at 9 and 12 months. This effect was however not significant at K2 level.

RRIC 100 also showed similar tendencies which became significant at K2 level (RRIC 100 showing significant effect at the end of 9 and 12 months and RRIC 121 at the end of 6 and9 months). The response in RRIC 103 had been in a different manner compared with other three clones where a decreasing trend in plant height was observed with the application of potassium at K1 level which became significant at K2 level at 6 and 12 months.

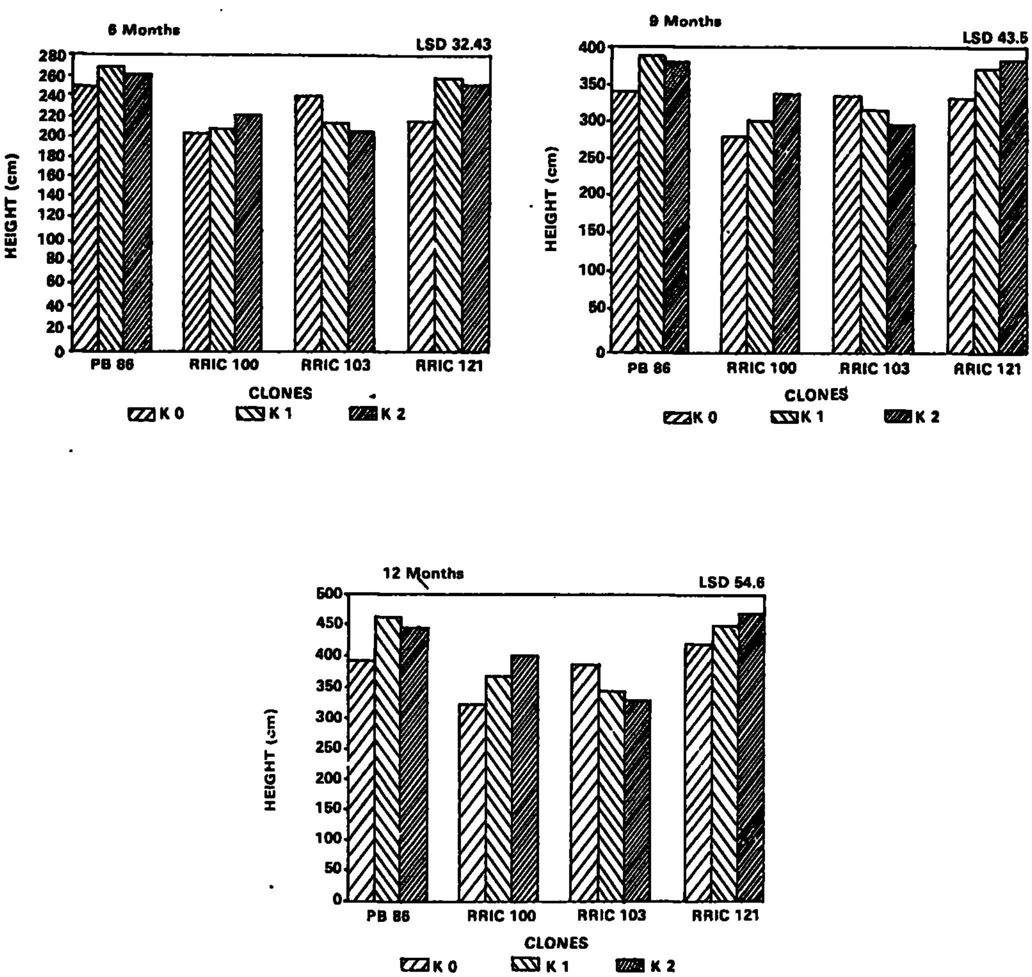

Fig. 5. Effect of levels of applied K on plant height of different clones.

Shoot Dry Weight

Shoot dry weight in experiment 1 showed a significant interaction ($P < 0.001$) between applied K and clones (fig 6). In RRIC 100, a linear effect was observed with K application at K2 level significantly increasing ($P < 0.01$) shoot dry weight over KO level. But in PB 86 the effect was quadratic where the Shoot dry weight was significantly increased ($P < 0.01$) with the application of potassium at K1 level. Further increase to K2 level of potassium showed a significant reduction ($P < 0.05$) in shoot dry weight compared with K1 level.

In experiment 2 shoot dry weight showed a significant interaction between applied levels of K and clones ($P < 0.05$) (fig. 7). PB 86 showed a significant increase in shoot dry weight at K1 level but this effect was not significant at K2 level. RRIC 100 and RRIC 121 showed a tendency to increase shoot dry weight which was significant for RRIC 100 at K2 level. But with RRIC 103 a decreasing tendency in shoot dry weight was observed with application of potassium at K1 level. This reduction in shoot dry weight was significant at K2 level.

Fig. 6. Effect of levels of applied K on shoot dry weight of clones.

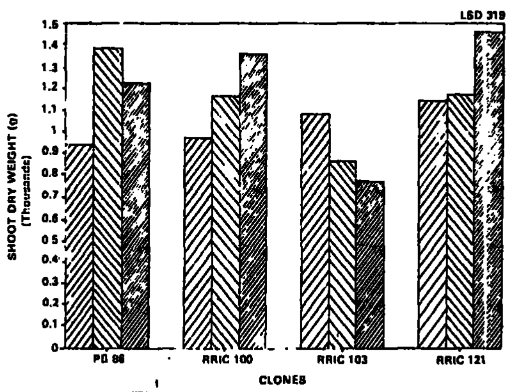

Fig. 7 Effect of levels of applied K on about dry weight of different clones.

Root Dry Weight

In experiment 1 there was a significant interaction ($P < 0.01$) between applied K and clones on root dry weight (fig. 8). The effects being similar to that with regard to shoot dry weight. With RRIC 100 there was a linear effect ($P < 0.01$) in increasing root dry weight with K application. In PB 86 also, there was a quadratic response, with K1 level increasing root dry weight significantly ($P < 0.05$) but at K2 level a significant reduction in root dry weight ($P < 0.05$) was recorded.

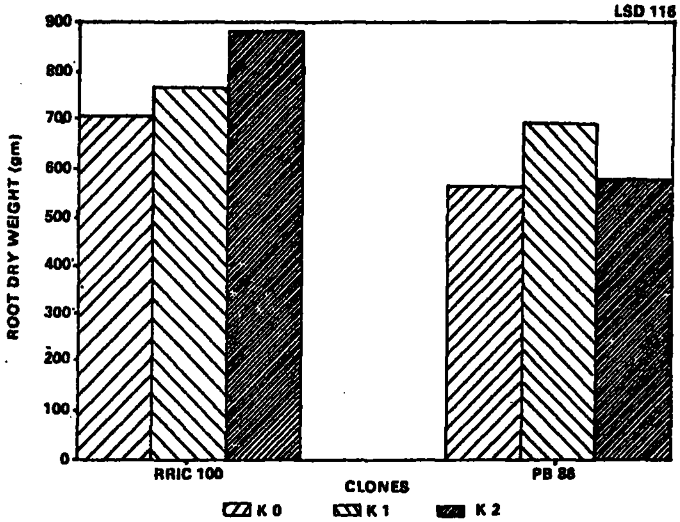

Fig. 8. Effect of levels of applied K on root dry weight of clones RRIC 100 PB 86.

Application of Mg in the form of Kieserite significantly ($P < 0.001$) increased root dry weight, but there was no effect when Mg was applied in the form of Dolomite. This effect was similar in all clones tested (table 4).

In experiment 2, root dry weight showed a significant interaction ($P < 0.05$) between applied Mg and clones (fig. 9). RRIC 103 showed an increase in root dry weight with the application of Mg becoming significant at Mg 2 level and was also significantly higher than M g 1 level. But in RRIC 100, application of magnesium at Mg1 level showed a tendency to supress root dry weight. This effect was however altered with the application of potassium at K2 level. Applied Mg however did not have any effect on the root dry weight of both PB 86 and RRIC 121.

Table 4. *Effect of sources of applied Mg on root dry weight and total dry weight.*

Source of Mg.	Weight (g)	
	Root dry weight	Total dry weight
Nil Mg	609.59	1,312.20
Kieserite	787.31***	1,634.46***
Dolomite	689.62	1,447.81
SED	41.87	84.07

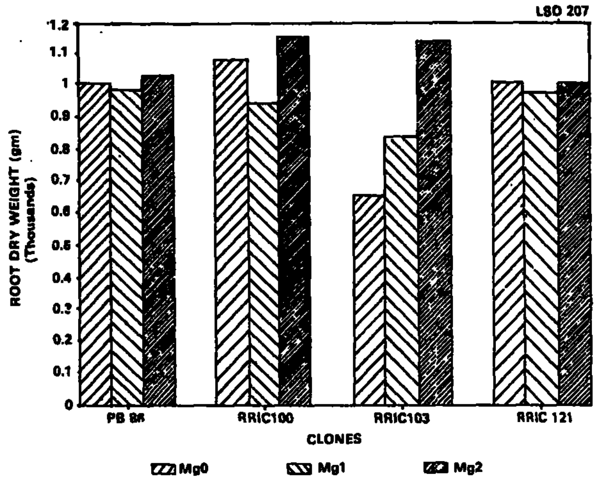

Fig. 9. Effect of levels of applied Mg on root dry weight of different clones.

Total Plant Dry Weight

In experiment 1 the effects of K application on total dry weight accumulation was similar to that of shoot and root dry weight changes (fig 10) with a significant interaction ($P < 0.01$) beween levels of K and clones.

Similary, the effect of applied Mg on total dry matter accumulation was similar to that of root dry weights (table 4).

In experiment 2 there was an interaction between applied K and clones (fig 11) where total dry weight was significantly increased in clones RRIC 100 and RRIC 121. But with PB 86 there was a significant increase in total dry weight with the application of potassium at K1 level, this effect was however not significant at K2 level as there was a tendency for total dry weight to be reduced with K2 level in comparision with K1 level.

Here again, RRIC 103 showed a decrease in total dry weight with application of K and this decrease became significant at K2 level confirming its peculiarity in response to applied K compared to the other three clones under consideration.

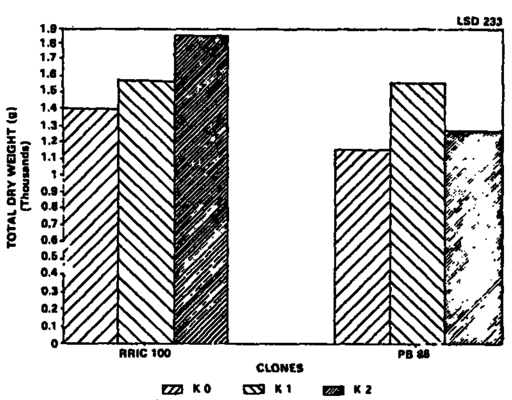

Fig. 10. Effect of levels of applied K on total dry weight of clones RRIC 100 and PB 86.

Fig. 11. Effect of levels of applied K on total dry weight of different clones.

There was a significant interaction between applied Mg and clones (fig 12) on total plant dry weight. In RRIC 103 application of Mg showed a tendency to increase total dry weight and this effect was significant at Mg2 level, but these effects were not seen in PB 86, RRIC 100 and RRIC 121.

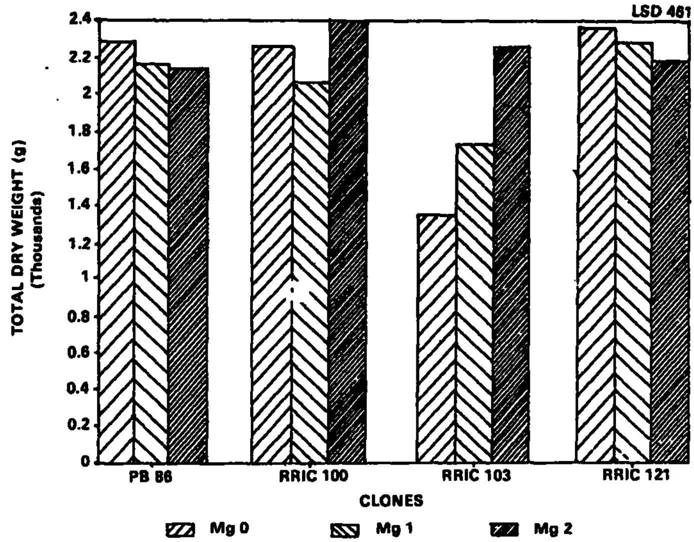

Fig. 12. Effect of levels of applied Mg on total dry weight of different clones.

Relative Growth Rate (RGR)

A significant interaction ($P < 0.05$) between applied K and clones on RGR (fig 13) was seen in experiment 1 with the effect of K on RRIC 100 being linear becoming significant at K2 level of application. PB 86 on the other hand showed a quadratic effect where the increase in RGR was only significant at K1 level. Further increase to K2 level however reduced RGR significantly.

An interaction between applied Mg and clones (fig 14) on RGR was observed in experiment 2. The differences in RGR were not significantly increased with application of magnesium at both Mg1 and Mg2 levels in comparision with the control ($P < 0.01$). The difference in effect between Mg1 and Mg2 was also significant ($P < 0.05$).

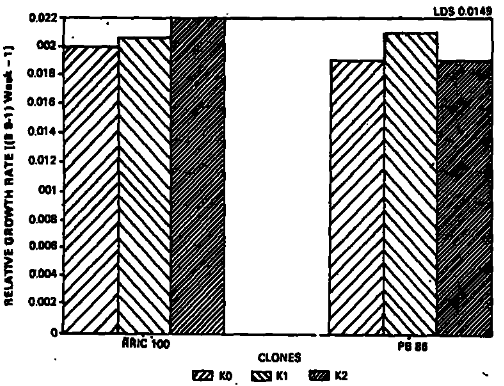

Fig. 13. Effect of levels of Applied K on relative growth rate of clones RRIC 100 and PB 86.

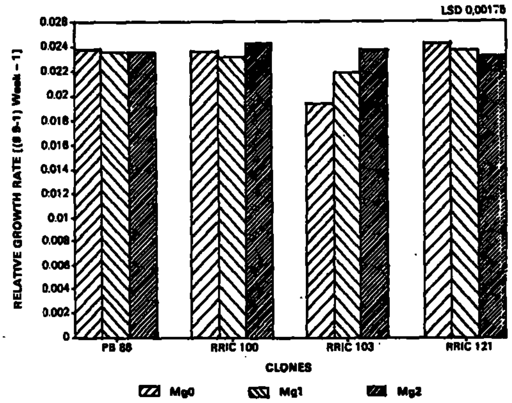

Fig. 14. Effect of levels of applied Mg on relative growth rate of different clones.

DISCUSSION

The pre treatment analysis of the soils used in this study (*Boralu* and *Homagama* series) indicated values of 0.04 and 0.07 me. of exchangeable potassium and 0.07 and 0.04 me. of exchangeable magnesium per 100g of soil in the *Boralu* and *Homagama* series soil respectively. Soils with these values for potassium and magnesium were considered to be deficient for normal growth of *Hevea brasiliensis* by Yogaratnam et al, (1984) under Sri Lankan conditions and Purshparajah (1977) under Malaysian conditions.

Growth responses due to application of potassium, expressed as stem diameter, plant height, shoot dry weight and total dry weight appear to vary between clones. Generally, the currently recommended close of 33 grams of K/plant/year (Anon, 1980) seems to be adequate for the clone PB 86 during the first year after establishment. But the recently introduced clon es such as RRIC 100 and RRIC 121 showed responses to higher levels of applied K. similar results of higher demand for potassium by vigorously growing clones were observed by Pushparajah et al., (1972) in some Malaysian clones. It appears that the recently developed clones, being more vigorous in growth, and with greater dry matter accumulation, would require higher levels of nutrients than the less vigorous clones such as PB 86, during the early stages of growth.

The consistant responses in girth shown by RRIC 103 to applied potassium has to be considered carefully as similar effects were observed in many of the growth parameters such as plant height, shoot dry weight, total dry weight and relative growith rate during the period of this study. Application of potassium at the recommended level showed a retarding effect on growth of this clone and when K was increased further to double level, there was a further retardation in girthing.

Although both clones RRIC 100 and RRIC 103 have the same parentage (RRIC 52 x PB 86) yet, some genetic differences may be a contributory factor for such effects. Moreover differences between these two clones on other characters such as vigour and susceptibility to diseases have also been reported by Jayasekera, (1987). As they are cross bred clones it is possible that the parents are highly heterozygous.

It appears that for clone RRIC 103, soil K level of approximately 0.04 me/100g is required for normal growth at least during the first 12 months after planting. Any increase is soil K leve l by additional fertiliser application is not only considered a waste, but also toxic to the ex tent of retarding growth.

The RGR data also showed similar effects suggesting that for PB 86, the currently recommended level of potassium is adequate for optimum growth. Increasing the level of potassium is adequate for optimum growth. Increasing the level of potassium beyond this rate would tend to decrease the efficiency of utiliziation of this nutrient for growth. But with RRIC 100 and RRIC 121 there had been a significant linear response to application of K suggesting that rates higher than the currently recommended level of potassium may be required for optimum growth of these clones at least during the first year of growth. The present practice is to give a uniform application of 33g of K per plant per year in the first year to all the clone s grown in Sri Lanka (Anon 1980).

The response to applied potassium in terms of increase in plant diameter (fig. 1 and 2), showed changes with age thus confirming the present practice of increasing the dosage of tertilisers with increase in age of the plant.

Under field conditions in experiment 3, where clonal effects were not cosidered, application of potassium at level 1 significantly increased plant diameter. But the fact that there had been no further increase in diameter to higher levels of potassium, suggests that for rubber grown under field conditions in general, in *Boralu* soils, 132g K is required for normal girth development during the the 30 months period. This finding however does not agree with the results obtained in experiments 1 and 2, possibly due to the fact that, the clones used in this experiment were PB 86 and RRIC 103 which have not shown good responses to higher doses of potassium in experiments 1 and 2 also. Also under field conditions one would not expect significant girth increases to applied fertilisers during first year of planting as the plants are still very young and the root system may not have developed fully. Therefore during this period growth assessment such as total biomass production would be a more reliable indicator. However from the second year onwards girthing should be used as the most appropriate indicator of growth as this parameter is normally used under commercial plantation conditions to assess the tree's tappable standards.

With regard to magnesium, reposnse in terms of total biomass production and RGR, clearly show that the application of magnesium is beneficial only to RRIC 103 in the first year from planting. All other clones tested viz PB 86, RRIC 100 and RRIC 121, were not benefited. RRIC 103 showed a significant increase in total biomass production and RGR at level 2 of applied magnesium, suggesting that in the solils having an average exchangeable Mg value 0.04 me/100g soil, it is necessary to apply magnesium fertiliser at double the presntly recommended amount for RRIC 103.

From 14 months after planting, however the position changes slightly in that, in general, Hevea brasiliensis clones could be expected to show increased growth in terms of higher rates of girthing as shown in the results of field experiment 3 on *Boralu* soils, to application of magnesium at levels higher than the currently recommended level i.e. 11g Mg per plant per year.

Although results from pot experiment 1 suggest that Kieserite, a readily soluble form of magnesium than Dolomite, experiment done under field conditions (experiment 3) did not show any significant differences between the sources of magnesium viz Kieserite, commercial epsom Salt or Dolomite. It is therefore possible to use Kieserite as the source of magnesium in the first year and then switch over to Dolomite, the cheapest source of magnesium available in Sri Lanka, and which is also a local product, thus saving considerable foreign exchange.

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REFERENCES

AKHURST, C. G. (1937). Manuring experiments on young rubber trees. Jl. Rubb. Res. Inst. Malaya. 8, 46.

ANANTH, K. C., George, C. H., MATHEW, M. AND UNNI, R.G. (1966). The report of fertilizer experiments with young rubber in South India. Rubb. Board Bull. No. 9, 30.

ANON (1980). Rubber Research Institute of Sri Lanka. Advisory Circular No. 85, February 1980.

BOLLE JONES, E. W. (1954 a). Nutrition of Hevea brasiliensis. I. Experimental methods. J. Rubb. Res. Inst. Malaysia.14, 183.

BOLLE JONES, E. W. (1954 C). Nutrition of Hevea brasiliensis III. The inter-relationships of Magnsium, potassium and Phosphorus. J. Rubb. Res. Inst. Malaya. 14, 209.

CONSTABLE, D. H. and HODNETT, G. E. (1953). The manuring of Hevea brasiliensis at Dartonfield, Ceylon. Emp. Agric. 21, 131 – 136.

FAIRFIELD SMITH, H. (1950). Effect of fertilizers on growth of Hevea. Jl. Rubb. Res. Inst. Malaya. 12, 266

JAYASEKERA, N. E. M. (1987), Head, Plant Breeding Department, Rubber Research Institute of Sri Lanka. Personal Communication.

JEEVARATNA, A. J. (1963). Review of the soils department. Annual Rev. 1963. Rubb. Res. Inst. Ceylon.

JEEVARATNAM, A. J. (1970). Relative importance of fertilizer application during pre and post tapping phases of Hevea Q. Jl. Rubb. Res. Inst. Ceylon 1970, 46, 52 – 50.

JOHN, R. S. (1967). The potassium status of some soils in the rubber growing areas of Ceylon Q. J. Rubb. Res. Inst. Ceylon. 43 (1 & 2)

LAU CHEE HENG (1979). Effect of potassium and aluminium treatments on growth and nutrient uptake of rubber seclings and on soils. J. Rubb. Res. inst. Malaysia. 27 (2), 92 – 103.

OWEN, G., WESTGARTH, D. R. and IYER, G. C. (1957). Manuring Hevea : Effect of fertilizers on growth and yield of mature rubber trees. J. Rubb. Res. Inst. Malaya. 15, 29.

PUNNOSE, K.I., POTTY S. N., MATHEW, M. and GEORGE, C. M. (1975). Responses ol Hevea brasiliensis to fertilizers in South India. Proc. Int. Rubb. Conf. Kuala Lumpur 1975. 84 – 104.

PUSPARAJAH, E. (1969). Response in growth and yield of Hevea brasiliensis to fertilizer application on Rengam series soils. Jl. Rubb. Res. Inst. Malaya. 21, 165.

pushparajah, E. (1977). Nutrition and fertilizer use in Hevea and associated covers in peninsula Malaysia – A Review, J. Rubb. Res. Ins. Sri Lanka (1977) 54 : 270 – 283.

RODERICK HUNT (1978). Plant Growth Analysis. The Institute of Biology's Studies in Biology No. 96.

SHORROCKS, V. M. (1960). Some effects of fertilizer applications on the nutrient composition of leaves and latex of Hevea brasiliensis. Proc. Nat. Rubb. Conf. Kuala Lumpur 1960. 180.

SILVA, C. G. (1971). An evaluation of the nutrient status of the rubber soils of Ceylon. RRIC Quart. Jl. 48 parts 3 – 4 147 – 159.

Von Vexkull, H. R. (1985). Potassium nutrition of some tropical plantation crops East and South East Asia program, Int. Pot. Inst. Singapore pp. 929 – 935

Watson, G. A. and Narayan, R. (1965). Effect of fertilizers on seed production of Hevea Brasukuebsus. Jl. Rubb. Res. Inst. Malaysia 19 (1), 22 – 31.

YOGARATNAM, N. SILVA, F. P. W. and WEERASURIYA, S. M. (1984). Recent developments in the nutrition of Hevea in Sri Lanka. Proc. Int. Rubb. Conf. Sri Lanka. I, 207 – 247.