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INFLUENCE OF FERTILIZERS ON GROWTH AND MINERAL COMPOSITION OF *HEVEA* SEEDLINGS GROWN IN THE FIELD NURSERY

by

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ABSTRACT

The effects of nitrogen, in the form of urea and ammonium sulphate, phosphate, pottassium and magnesium manuring on various aspects of plant performance were studied on Hevea seedlings grown for the purpose of green budding. Both urea and ammonium sulphate significantly enhanced plant performance in terms of plant height, stem diameter and mineral composition of leaves and the acceptable levels of appliction appear to be in the region of 15.6 *and* 34.0 *g/plant with urea and ammonium sulphate, respectively. Significant linear effects of applied nitrogen decreasing leaf Ca content were also observed. Although applied pottassium and magnesium increased their respective leaf nutrient contents, they failed to influence plant growth during the nursery stage. Applied P in the form of rock phosphate, did not influence leaf P content, but increased soil Ca content.*

INTRODUCTION

Many workers have studied, the nutritional requirements of both immature and mature *Hevea* grown in the field (Bolle Jones, 1954 a,b,c; Bolton and Shorrocks 1965; Guha and Pushparajah, 1966; Yogaratnam and Silva 1977; Yogaratnam and Weerasuriya, 1984; Yogaratnam *et al* 1984; Yogaratnam and de Mel 1985). However information on the nutrient requirements of *Hevea* seedlings grown in the field nursery is limited. Investigations by Yogaratnam and Karunaratne (1972), on fertilizer responses in *Hevea* seedlings grown in the field nursery showed that the application of fertilizers in repeated small doses is unlikely to be more beneficial than less frequent application of correspondingly larger amounts.

This study was undertaken to assess the nutritional requirements of *Hevea* seedlings grown in the field nursery for green budding purposes as virtually no work has been done on this aspect.

MATERIALS AND METHODS

Two experiments were started in a seedling nursery, at the RRISL sub station in Nivithigalakale, planted in September 1985, to study the effects of levels of N,P,K, and Mg on growth and mineral composition of *Hevea* seedlings that are to be used for green budding.

In both experiments a 3^4 factorial confounded design was used to accomodate 81 treatment combinations with all possible combinations of N,P,K, and Mg.

Urea, rock phosphate, Muriate of potash and kieserite were used in the first experiment but ammonium sulphate was used as the source of nitrogen in the second experiment instead of Urea. The three levels of nutrients tested are given in Table 1.

Table 1. *Sources and levels of nutrients tested*

Nutrient	Source	Levels (g/plant) 0*	1**	2***
Nitrogen	Urea – (46%N)	0	15.6	31.2
	Ammonium sulphate (21%N)	0	34.0	68.0
Phosphorus	Rock phosphate (28.5% P_2O_5 and 11% CaO)	0	30.0	60.0
Potassium	Muriate of potash (60% K_2O)	0	14.4	28.8
Magnesium	Kieserite (24% Mgo and 22% S	0	20.0	40.0

* Nil

** Currently recommended level

*** Double the recommended level

Experimental layout

In both experiments, each plot consisted of 10 seedlings planted in pairs of rows in a 21cm triangular spacing with 60cm space between the centre adjacent pairs of rows. Provision was also made for additional plants as guard rows on all four sides.

First application of fertilizers was done when the plants were one month old and the second at the age of three months.

Measurements

As root stock stem diameter is considered a convenient parameter for assessing the tree growth (Jayasekera and Senanayake, 1971), and present practice of deciding on the buddability of plants is also based on stem diameter, this parameter was measured in this study. Diameter of each plant at 15 cm above the collar region was measured at the age of one, two and six months. Plant height was also measured at the same time.

Green budding was done at the end of 6 months using clone RRIC 121 and the successful grafts were counted 3 weeks after budding.

As leaf nutrient concentration is controlled primarily by the nutrient supply (Yogaratnam and Silva, 1977), leaf samples were collected at the end of 2 and 6 months after planting from the second whorl to determine the leaf N,P,K,Ca and Mg contents. Top soil, upto a depth of 10 cm, was sampled at the end of the experiments and analysed for soil, total N, total and available P, total and exchangeable K and Mg contents.

Analytical method

N and P in leaf and soil were determined by colorimetry and K in leaf was determined by flame emmission spectorphotometry. Leaf Ca, Mg, and soil K, Ca and Mg were determined by atomic absorption spectrophotometry.

RESULTS

All data were subjected to analysis of variance and statistically significant effects were partioned into linear and quadratic components. The statistical significance is always indicated by the standard error of difference (SED) and in all the tables *, ** and *** denote that treatments are significantly different from the control at $P=0.05$, 0.01 and 0.001 levels, respectively.

Plant height

In experiment 2, plant height was significantly increased ($P < 0.01$) by application of nitrogen at N_1 levels when nitrogen application was increased to N_2 level, there was a tendency for plant height to get retarded in growth (Table 2).

Table 2. *Effect of applied N on plant height (Experiment 2)*

Levels of applied N	Plant height (cm)	Increase over control (%)
N_0	104.1	100
N_1	113.9**	109
N_2	108.8	105
SED	3.6	3.5

There were no effects of applied P, K, or Mg on plant height in both experiments and applied N in experiment 1.

Stem diameter

Although application of nitrogen at N_1 level did not influence stem diameter at the end of 2 months after planting, there was a significant increase in stem diameter at the end of 6 months in both experiment 1 ($P < 0.05$) and experiment 2 (P < P0.001). However, increasing the level of applied nitrogen to N_2 did not have any further effect on stem diameter (Table 3).

Table 3. *Effect of applied N on stem diameter*

Levels of applied N	Stem diameter (mm)	Increase over (%)	Stem diameter (mm)	Increase over control (%)
N_0	8.863	100	9.218	100
N_1	9.541*	108	10.450***	113
N_2	9,541*	108	10.100***	110
SED	0.287	3.19	0.251	2.72

Stem diameter increment (Table 4) over the last 5 month period expressed in relation to diameter at the end of one month was significantly increased by applied nitrogen in both experiments and applied magneisum in experiment 2. There were significant quadratic effects of applied nitrogen at 1% and 0.1% levels in experiment 1 and experiment 2, respectively. Applied magnesium showed a tendency for higher stem diameter increment in experiment 1 and this effect was significantly quadratic ($P < 0.001$) in experiment 2.

Table 4. *Effect of applied nitrogen and magnesium on stem diameter increment*

Levels of applied nutrients	Diameter Increment Experiment 1	Diameter Increment Experiment 2
N_0	1.635	1.994
N_1	1.835*	2,454***
N_2	1.889**	2,361***
SED	0.081	0.075
Mg_0	1.776	2.119
Mg_1	1.709	2.250
Mg_2	1.874	2,440***
SED	NS	0.075

There were no effects of applied P,K, and Mg on stem diameter in both experiments.

Buddability

Green budding was done on all plants that attained a stem diameter of 1cm using buds from clone RRIC 121. Statistical analysis was done only on experiment 2 as there were insufficient plants for this assessment in experiment 1. This data shows that the percentage of buddable plants were significantly ($P < 0.01$) increased by application of nitrogen at N_1 level and no further significant effect was recorded when nitrogen was increased to N_2 level (Table 5).

Table 5. *Effect of applied N on buddability (Experiment 2)*

Levels of applied N	Buddability %	Increase over control %
N_0	63.66	100
N_1	75.05***	118
N_2	70.01	110
SED	4.069	6.39

There were no effects of applied P,K, and Mg on this parameter.

Mineral composition of leaves

Leaf Nitrogen: There has been significant increases in leaf N content at the end of 2 months from planting (Table 6) and these effects were significantly quadratic in both experiment 1 ($P < 0.05$) and experiment 2 ($P < 0.01$). But at the end of 6 months the effect of applied N on leaf N content were significantly linear ($P < 0.001$) in both experiments. In both experiments the rate of increase in leaf N content per unit application of N in the form of urea or ammonium sulphate had been approximately 0.32,

Table 6. *Effect of applied nitrogen on leaf N content (%) at the end of 2 and 6 months after planting* .

Levels of nitrogen	Experiment 1 (Urea) 2months	6months	Experiment 2 (Ammonium Sulphate) 2months	6 month
N_0	3.81	3.431	3.23	3.144
N_1	3.72	3.723	3.93***	3.607***
N_2	3.97*	4.058***	4.09***	3.791***
SED	0.066	0.129	0.099	0.106

There were no consistent and significant effects of applied P, K and Mg on leaf N content during the course of the experiment.

Leaf Phosphorus : There were no consistant and marked effects of treatments on leaf phosphorus content in both experiments.

Leaf potassium: Application of nitrogen in experiment 1 where urea is the sourec of nitrogen increased leaf K content at the end of 2 months and this effect was significantly quadratic ($P < 0.05$). But at the end of 6 months, there was a significant decrease in the leaf K content with application of N, this effect being significantly linear ($P < 0.05$) (Table 7). However, in experiment 2, leaf K content has been consistantly decreased by application of nitrogen and the effects were significantly quadratic ($P < 0.001$) at the end of 6 months.

Leaf K contents were consistantly increased by application of potassium, the effects being significantly quadratic ($P < 0.01$) at the end of 2 months in both experiments and significantly linear ($P < 0.001$) at the end of 6 months in experiment 1 and significantly quadratic ($P < 0.001$) in experiment 2 (Table 7).

Table 7. *Effect of applied nitrogen and potassium on leaf K content (%) at the end of 2 and 6 months*

Levels of nutrients	Experiment 1		Experiment 2	
	2 months	6 months	2 months	6 months
Nitrogen				
N_0	0.097	1.236	0.952	1.287
N_1	0.982*	1.192	0.841*	1.123
N_2	0.918	1.105*	0.822*	1.060***
SED	0.022	0.057	0.021	0.031
Potassium				
K_0	0.932	0.960	0.775	0.864
K_1	0.875	1.168	0.911	1.223
K_2	0.999**	1.405***	0.930**	1.383***
SED	0.022	0.057	0.021	0.031

Application of Mg showed a tendency to decrease K content in both experiments but this effect was significantly quadratic ($P < 0.05$) only in experiment 2 at the end of 6 months form planting. The leaf K content was decreased from 1.253% to 1.110% when Mg was applied at Mg_1 level and a further reduction in leaf K content to 1.107% was recorded when Mg application was increased to Mg_2 level. Phosphate application however did not have any effect on the leaf K content in both experiments.

Leaf Magnesium: Application of potassium showed tendencies to decrease leaf Mg content at the end of 2 months in both experiments but this effect was significant at the end of 6 months. In experiment 1 there was a significantly linear ($P < 0.001$) negative effect in application of potassium decreasing the leaf Mg content and in experiment 2, the same effect was significantly quadratic ($P < 0.001$) (Table 8).

Magnesium application on the other hand consistantly increased the leaf Mg content (Table 8) as to be expected, the effects being significantly linear ($P < 0.001$) at the end of 2 months and 6 months in experiment 1 and at the end of 2 months in experiment 2. However in experiment 2 at the end of 6 months, the increase in leaf Mg content was significantly quadratic ($P < 0.001$).

Table 8. *Effects of applied potassium and magnesium on leaf Mg. contents (%)*

Levels of nutrients	Experiment 1		Experiment 2	
	2 months	6 months	2 months	6 months
Potassium				
K_0	0.245	0.307	0.260	0.325
K_1	0.249	0.263	0.240	0.252***
K_2	0.228	0.251***	0.237	0.229***
SED	NS	0 014	NS	0.011
Magnesium				
Mg_0	0.227	0.228	0.219	0.210
Mg_1	0.235	0.277	0.239	0.297
Mg_2	0.261***	0.317***	0.280***	0.300***
SED	0.012	0.014	0.013	0.011

Application of nitrogen and phosphate did not have any effects on leaf Mg content in this study.

Leaf calcium : Application of nitrogen consistantly decreased the Ca content in the leaves in both experiments at both assessments (Table 9). The decrease in the leaf Ca content was significantly linear ($P < 0.001$) at the end of 2 months in experiment 1 and also at 1% level of significance at the end of 6 months in experiment 1 and at the end of 2 and 6 months in experiment 2. The rate of decrease per unit application of N had been approximately 0.04 and 0.05 at the end of 2 and 6 months respectively as shown in figure 1.

Table 9. *Effect of applied nitrogen on leaf Ca content (%)*

Levels of nitrogen	Experiment 1		Experiment 2	
	2 months	6 months	2 months	6 months
N_0	0.570	0.789	0.601	0.625
N_1	0.515	0.711	0.523	0.574
N_2	0.483***	0.680***	0.510**	0.523**
SED	0.021	0.035	0.025	0.030

There were no effects of applied P. K and Mg on leaf Ca contents in this investigation.

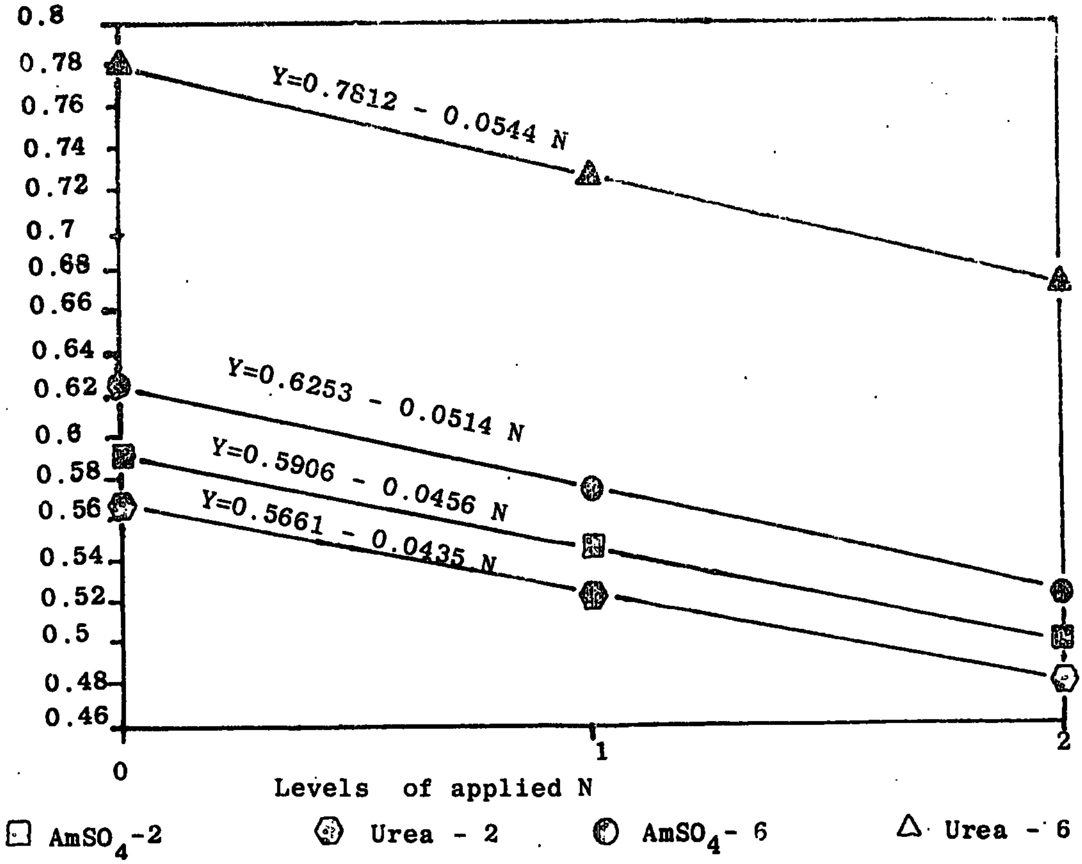

Fig. 1. Effects of levels of applied N on leaf Ca content

Soil nutrient contents

Nitrogen and Phosphate: There were no effects of applied nutrients on soil N and P contents in both experiments during the period of this study.

Potassium: The effects of application of N, K and Mg on soil K content is given in Table 10.

Table 10. *Effect of applied N, K and Mg on soil K content (ppm) 3 months after fertilizer application*

Applied Nutrients	Soil K content Experiment 1		Experiment 2
K_0	32.348	K_0	23.348
K_1	92.985***	K_1	65.926***
K_2	145.385***	K_2	92.122***
Mg_0	126.174	N_0	73.993
Mg_1	79.270***	N_1	55.048*
Mg_2	65.274***	N_2	52.405*
SED	11.75	SED	8.60

Application of nitrogen decreased soil K content in experiment 2 only and this effect was significantly qudratic ($P < 0.05$).

Potassium application at K_1 level was found to significantly increase ($P < 0.001$) soil K content and a further increase in the application of K to K_2 level resulted in a further significant increase ($P < 0.001$) in soil K content in experiment 1. Similar significant ($P < 0.001$) effects of applied K increasing the soil K content was recorded in experiment 2 also. This effect was observed three months after potassium containing fertilizer was applied.

Soil K content was found to be significantly reduced ($P < 0.001$) by application of Mg fertilizer and this effect was not significantly different between levels of applied Mg.

Magnesium: Application of Mg at Mg_1 level significantly increased ($P < 0.001$) soil Mg content in experiment 1 and a further increase in the application of Mg to Mg_2 level, significantly increased ($P < 0.001$) soil Mg content further (Table 11). Similar significant increases ($P < 0.001$) in soil Mg content were recorded in experiment 2 also.

Table 11. *Effect of applied Mg on soil Mg content (ppm)*

Levels of applied Mg	Soil Mg content Experiment 1	Experiment 2
Mg_0	16.432	7.346
Mg_1	75.981***	23.848***
Mg_2	96.140***	29.363***
SED	7.320	2.950

Calcium; In both experiments the soil Ca contents were significantly increased by application of rock phosphate (Table 12), as expected. The effect in experiment 1 was significantly linear ($P < 0.001$) and in experiment 2 the increase in Ca content was significantly quadratic ($P < 0.001$)

Table 12. *Effect of applied P on soil Ca content (ppm)*

Levels of applied P	Soil Ca content Experiment 1	Experiment 2
P_0	113.08	40.45
P_1	320.65***	192.66***
P_2	543.73***	247.92***
SED	54.458	22.639

DISCUSSION

Leaf analyses provide abundent evidence of the uptake of N, K and Mg from applied nitrogen, potassium and magnesium fertilizers. Both urea and ammonium sulphate were equally effective in increasing the leaf N content at the rate of 0.32 per unit of applied nitrogen. Although a small amount of urea applied to the soil may be taken up directly by the plant (Webster, 1959) the major portion is first converted to inorganic nitrogen (ammonium) before absorption. Gibson (1930) suggested that the conversion of organic urea to inorganic ammonium carbonate in the soil is a biological process initiated by microorganisms which contain the enzyme urease. Silva and Perera (1971) studying the urease activity in the rubber soils of Sri Lanka, observed that the levels of activity in these soils are statisfactory for the conversion of urea into available forms to the plants. Urea was known to be as effective as ammonium sulphate as a nitrogen fertilizer for immature and mature rubber. Yogaratnam and Perera (1981) and Yogaratnam (1987) confirm their effectiveness in the seedling nursery also.

The increases in leaf nutrient contents due to fertilizer application, varying from 0.627 to 0.647% for nitrogen, 0.445 to 0.519% for potassium and 0.089 to 0.99% for magnesium can in general be considered large by previous studies of Yogaratnam and de Mel (1985) in Sri Lanka, Pushparajah (1969) in Malaysia and Guha (1975) in Liberia. The absence of significant increases in leaf P content due to application of phosphate fertilizers was not surprising as it is known that the lag period between first application of phosphorus and increase in leaf P is longer than for leaf N and K (Yogaratnam and de Mel, 1985) possibly due to higher levels of available P in the soil prior to the commencement of the experiment. More soluble forms of phosphate such as superphosphate may have improved this effect, but at the same time in granite derived acid soil used in this study, a considerable portion of P may have been fixed as calcium, aluminium and iron phosphates (Lan *et al*, 1973) although a large portion of this residual P in the iron and aluminium fraction. may be available to plants subsequently (Pushparajah *et al*, 1975).

There are several known nutrient antagonism in *Hevea* nutrition and these effects appear to be exhibited by young *Hevea* seedlings also as seen in this study. Nitrogen application was found to decrease leaf K and Ca contents with ammonium form showing a more pronounced effect on leaf K as reported by Shorrocks (1960) and Yogaratnam *et al* (1984), potash fertilizer decreased leaf Mg content as observed by Yogaratnam and Perera (1981). and Mg fertilizers also reduced leaf K content, confirming the observations of Yogaratnam and Weerasuriya (1984). The consistent negative linear response to applied N on leaf Ca content seems to suggest that Ca status of *Hevea* plants can be monitored by applied nitrogen and this may be considered important in *Hevea* nutrition as pre-coagulation of latex in mature rubber trees due to excessive Ca in the tree is known (Southern and Edwin, 1968),

Normally, an increase in the concentration of a particular mineral constituent will not necessarily influence growth, unless the change is affected within the range of critical concentrations associated with the development of the deficiency. Yogaratnam *et al*, (1984) considered total nitrogen content of the soil in the range of 0.185 to 0.205% unlikely to be sufficient for normal performance of immature rubber. It is possible that deficient values for soil nitrogen in the range of 0.16 to 0.25% in this study may have promoted responses both in terms of increased nitrogen content of leaves as well as improved growth, although soil N content did not show any significant changes due to applied nitrogen. On the contrary, although the leaf nitrogen content in the control plots were in the range of 3.144 to 3.431% which are the normal values exhibited by healthy *Hevea* seedlings (Shorrocks 1964), significant increases in plant height, stem diameter, stem diameter increment and percentage buddability have been recorded with application of nitrogen at N_1 level. It therefore appears that the critical range for leaf N content may be slightly higher for seedlings grown in the field nursery than for seedlings grown in sand culture by Shorrocks (1964). It is also known that nitrogen enhances various aspects of growth and development in *Hevea* and that total aerial biomass is generally increased by nitrogen (Sivanadyan and Ghandimathi, 1985). Results from this study also indicate that nitrogen applications at amounts higher than the normal rate might decrease plant height but whether this would enhance root, leaf or reproductive development is not known.

However, as mentioned earlier, the plant mean girth is normally the criterion used for tree selection, since evidence from the literature indictaes good correlations between girth and tree weight, girth is used as the standard criterion to estimate growth, buddability and tappability both for experiments and in estate practice for *Hevea* exploitation. From the present study, it therefore appears that application of nitrogen at level 1 appears to be most suitable for *Hevea* seedlings grown in the field nursery for the purpose of green budding. As for other nutritients, it is not very clear whether, P. K and Mg would be essential under normal conditions where their concentrations in the soil are considered adequate (Yogaratnam *et al.* 1984). Nevertherless, the normally accepted criterion of success of nursery fertilization is the proportion of seedlings which would attain the standards for buddability prior to green budding and ultimately the field performance of these budgerafts. Therefore the performance of plants in the field in relation to various fertilizer treatments in nursery, should also be assessed. This investigation was done merely to study the effects of fertilizer treatments on *Hevea* seedlings up to the green budding stage only, and this investigation will be continued further to correlate growth in the nursery with the subsequent field performance of budded plants and it is possible that the effects of other nutrients such as P, K and Mg may begin to appear.

Under normal estate practices, Ca is not applied to the soil in the form of fertilizers. However, it appears that the Ca requirements of the soil used for *Hevea* cultivation may be satisfied by the application P in the form of rock phosphate as the Ca content of the soil was increased by application of rock phosphate in this study.

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