

FERTILIZER RESPONSES IN *HEVEA BRASILIENSIS* SEEDLINGS GROWN IN THE FIELD NURSERY

By

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INTRODUCTION

Nutritional requirements of *Hevea brasiliensis* have been investigated by many workers both in sand culture (Bolle-Jones, 1956) and in the field (Constable, 1953; Bolle-Jones, 1954 a, b, c; Constable & Hodnet 1959; Bolton & Shorrocks 1961; Compagnon, 1962). These investigations resulted in emphasis being placed on N P and K in fertilizers for rubber. Recognition of a widespread need for magnesium subsequently led to the incorporation of magnesium in the form of magnesium sulphate in the NPK fertilizer mixtures (Jeevaratnam, 1959). However, information on the nutrient requirements of *Hevea* seedlings grown in the nursery is limited. The results of an experiment laid down in 1958 and reported in 1961, to study the effect of magnesium added to NPK fertilizers on the growth of *Hevea* plants in a seedling nursery of the Institute, indicated that addition of magnesium as commercial epsom salt had no significant effect on their growth up to a period of 2 years. However, subsequent studies (Jeevaratnam, 1962) have shown a significant benefit by the addition of magnesium, although there was no difference between epsom salt and dolomite as sources of magnesium (Jeevaratnam, 1962). This trial also indicated that manuring with animal meal has no particular advantage over inorganic fertilizers. Results reported in this paper deal with economic levels of N P K and Mg and the optimum number of fertilizer applications.

MATERIALS AND METHODS

Three experiments were laid down in a seedling nursery planted in September 1969, at the Institute's experimental station. The results of two of these experiments are reported here. In the first, a 3⁴ factorial layout was used to accommodate 81 treatment combinations with all possible combinations of N P K and Mg at three levels, (0, 1 and 2). The nutrients, their source and levels under investigation are given in Table 1.

TABLE 1
SOURCES AND LEVELS OF NUTRIENTS TESTED

Nutrient	Source	Levels (oz/plant/year)		
		0	1	2
Nitrogen	Sulphate of ammonia (21% N)	0	2	4
Phosphorus	Saphos phosphate (28% P ₂ O ₅)	0	2	4
Potassium	Muriate of potash (50% K ₂ O)	0	1	2
Magnesium	Commercial epsom salt (26% MgO)	0	1	2

In the second experiment five frequencies of fertilizer application were tested in a randomized block design with four replicates (2,3,4,5 and 6 per year). All plots received a uniform quantity of fertilizer at the rate of 2 oz sulphate of ammonia 2 oz of saphos phosphate, 1 oz of muriate of potash and 1 oz of epsom salt per year.

Layout of beds : In both experiments, each plot consisted of 10 germinated seeds planted in pairs of rows on a 9" triangular spacing, with a 2 ft space between the center of adjacent pairs of rows. This provided access to the plants for budding and other operations. Provision was also made for additional plants along guard rows. Seed germination techniques were similar in both experiments. Tjir 1 seeds were germinated in a sand bed and rogued for abnormalities. One good seven-day old seedling was planted at each point.

Fertilizer dosages were applied at intervals of three months commencing from October 1969, for the NPK Mg experiment and for the frequency of fertilizer application experiment according to experimental treatments.

Measurements : The use of root stock stem diameter was suggested as a convenient parameter of growth by Jayasekera & Senanayake (1971), on the basis of their findings that root stock diameter is significantly correlated with other growth characters such as plant height and leaf area. Moreover the present practice of deciding whether the plants in the nursery are ready for budding is also based on diameter measurements. Therefore, this parameter is used in this study. Diameter of each plant at 12" above the collar was measured at six, seven, eight, twelve, fourteen and sixteen months after planting and leaf samples were collected at the end of sixteen months to analyse for N, P, K, Mg and Ca. The samples were collected from all plants before 11.00 a.m. The leaves sampled were the two largest leaves at the base of the uppermost mature whorl on the date of collection (Chapman, 1941).

Analytical method : Nitrogen was determined by the standard micro-Kjeldahl method, phosphorus colorimetrically using ammonium vanadomolybdate and potassium by flame emission spectrophotometry. Magnesium and calcium were determined by the EDTA titration method using Eriochrome Black T as the indicator and calcium by the potassium permanganate-oxalate titration and magnesium by the difference (Piper, 1950).

RESULTS

Growth response : The diameter measurements recorded at six, seven, eight, ten, twelve, fourteen and sixteen months after planting are presented in Table 2. The diameter increment was influenced by nitrogen, from a period of six months from planting till the end of the experiment. Mean diameters at the end of 16 months were 2.349 and 2.344 cm respectively for the N_1 and N_2 levels of nitrogen, compared to only 1.811 cm for the N_0 treatment.

TABLE 2
GROWTH RESPONSE TO FERTILIZER TREATMENTS OVER A PERIOD OF 16 MONTHS
MEAN DIAMETER (CM)

Treatments	Period after planting (months)						
	Six	Seven	Eight	Ten	Twelve	Fourteen	Sixteen
N_0	0.64 ***	0.74 ***	0.84 ***	1.12 ***	1.33 ***	1.66 ***	1.81 ***
N_1	0.75	0.88	1.13	1.50	1.83	2.20	2.35
N_2	0.76	0.92	1.09	1.54	1.81	2.20	2.34
P_0	0.71	0.83	0.97	1.34	1.57	1.91	2.04
P_1	0.71	0.84	1.02	1.39	1.66	2.01	2.18
P_2	0.74	0.88	1.07	1.44	1.74	2.14	2.28
K_0	0.73	0.84	1.03	1.38	1.62	1.98	2.09
K_1	0.71	0.86	1.02	1.41	1.67	2.04	2.19
K_2	0.71	0.84	1.02	1.38	1.68	2.04	2.22
Mg_0	0.71	0.85	0.99	1.38	1.66	2.05	2.19
Mg_1	0.70	0.84	0.99	1.38	1.65	2.06	2.24
Mg_2	0.74	0.86	1.08	1.41	1.65	1.96	2.09
L.S.D. (P=0.05)	0.06	0.06	0.14	—	0.16	0.19	0.22

This represents an average increase of 30% over a period of 16 months. Increasing nitrogen from N_1 to N_2 level has however resulted in no further increase in diameter. The overall response is significantly quadratic. The maximum growth of 2.349 cm was recorded in plots that received the N_1 level. Response to phosphorus increased linearly with time reaching significance at the end of 12 months and this response was maintained till the end of the experiment. A mean diameter of 2.284 cm was recorded in plots that received the highest level of phosphorus (P_2). This represents an increase of 8% over the plots that did not receive any phosphorus. Potassium at K_1 level increased diameter by 5% over the K_0 plots though this was not significant. However, increase beyond the K_1 level did not give any substantial increase in growth. There is no evidence of any significant response to magnesium, but there is a slight reduction in growth at the highest level of Mg, although this is not significant. The interaction between nitrogen and phosphorus is not significant, and the growth of 2.45 and 2.48 cm attained by plants that received fertilizers at N_1P_1 and N_2P_2 levels, respectively, are comparable (Table 3). Similarly, there was no N:K interaction and the first level of NK gave the best growth (2.53 cm).

TABLE 3

EFFECT OF INTERACTION BETWEEN THE LEVELS OF NITROGEN AND PHOSPHORUS AND NITROGEN AND POTASSIUM ON GROWTH AT THE END OF 16 MONTHS MEAN DIAMETER (CM)

	P_0	P_1	P_2	K_0	K_1	K_2
N_0	1.66	1.77	2.02	1.82	1.71	1.91
N_1	2.22	2.45	2.31	2.12	2.53	2.39
N_2	2.24	2.31	2.48	2.34	2.33	2.36

The results presented in Table 4 on the frequency of fertilizer application, indicate that increasing the number of applications of fertilizer from two per year to six per year did not give any significant increase in diameter over the 16 month growth period. Nevertheless, the plants that received fertilizer in six split doses recorded the best growth of 2.59 cm at the end of the experiment.

TABLE 4

EFFECT OF FREQUENCY OF FERTILIZER APPLICATION ON GROWTH OVER A PERIOD OF SIXTEEN MONTHS MEAN DIAMETER (CM)

Treatments (applications per year)	Period after planting (months)					
	Six	Seven	Eight	Thirteen	Fourteen	Sixteen
2	0.80	0.93	1.06	1.79	2.07	2.24
3	0.80	1.00	1.11	1.57	1.99	2.22
4	0.80	1.01	1.10	1.67	1.98	2.16
5	0.80	0.95	1.04	1.50	1.91	2.05
6	0.84	1.01	1.18	1.94	2.45	2.59
L.S.D. (P=0.05)	0.09	0.13	0.21	0.37	0.53	0.37

Leaf nutrient content : Application of nitrogen increased the nitrogen content of leaves (Table 5). Nitrogen had a positive effect on the N content of leaves though it failed to reach significance. Application of nitrogen at N₁ level increased the leaf N content from 3.12% to 3.19%—an increase of 2%. A further increase to the N₂ level resulted in an increase to 3.24%, a 4% increase over the control. Phosphorus application did not show any effect on the N content of the leaf, but potassium and magnesium fertilizers have had an effect. When potassium was increased from the K₀ to the K₁ level there was an increase in leaf nitrogen content from 3.17% to 3.24%. This is in agreement with the findings of Shorrocks (1960). However, a further increase to the K₂ level resulted in the decrease of N content to 3.14%. A similar depressing effect was observed with magnesium fertilizer. Sulphate of ammonia had a negative effect on the phosphorus and potassium content of leaves.

TABLE 5

EFFECT OF FERTILIZER APPLICATION ON NUTRIENT CONCENTRATION IN LEAVES

Treatment	Nutrient concentration in leaves			
	N (%)	P (%)	K (%)	Mg (%)
N ₀	3.12	0.23	1.09	0.27
N ₁	3.19	0.20	0.92	0.25
N ₂	3.24	0.19	0.82	0.27
P ₀	3.17	0.20	0.96	0.25
P ₁	3.18	0.21	0.98	0.26
P ₂	3.19	0.21	0.91	0.27
K ₀	3.17	0.21	0.86	0.27
K ₁	3.24	0.20	0.93	0.27
K ₂	3.14	0.20	1.07	0.25
Mg ₀	3.23	0.21	0.97	0.24
Mg ₁	3.13	0.20	1.03	0.25
Mg ₂	3.19	0.21	0.85	0.29
L.S.D. (P = 0.05)	—	0.01	0.12	0.04

DISCUSSION

The criteria of success of nursery fertilization are the proportion of seedlings, which would attain the standards for buddability, on the last date of growth assessment, and ultimately the field performance of these budgrafts. Therefore, the performance of plants in the field in relation to various treatments in the nursery should be assessed. The experiments discussed here were laid down merely to assess the response of nursery plants to different levels of nutrients and to arrive at an optimum level of fertilization. Further studies will be undertaken to correlate growth in the nursery with the subsequent field performance of plants.

The growth condition of the shoot can so influence its leaf nutrient content, that a single sampling of nursery leaves is not likely to give a true picture of its nutrient content. Non-structural nutrients may be diluted whereas structural nutrients may increase in proportion to leaf size. Therefore, leaf analysis figures presented here are probably of limited value.

The results presented show that nitrogen and phosphorus are very important for growth of young plants in seedling nurseries. Nitrogen gave a consistent response throughout the growth period in the nursery. The response was significantly quadratic. A corresponding proportionate increase in leaf nutrient content of 2% when nitrogen was increased from N_0 to N_1 and a further increase at a lower rate, with an increase from N_1 to N_2 level were observed. These results indicate (Fig. 1) that addition of nitrogen beyond the N_1 level is unlikely to be beneficial. In contrast, there was a marked response to phosphate which is significantly linear (Fig. 2). The plants that received the highest level (P_2) exhibited the best growth of 2.284 cm, an 8% increase from the lowest level. This shows that young *Hevea* seedlings are likely to benefit from relatively high levels of phosphate fertilizer. The pattern of response seems to be very much similar to that observed by Jeevaratnam (1969) on growth of *Hevea* during the immature phase. Even though response to potassium and magnesium was lacking, this does not justify the elimination of these nutrients from the standard fertilizer mixtures. Lack of response to potassium may be due to the application of higher levels of N which has probably depressed the uptake of potassium. A similar negative effect of the higher levels of nitrogen in decreasing the leaf potassium content was reported by Shorrocks (1960), and Bolton & Shorrocks (1961). Cain (1953) also reported that nitrogenous fertilizers depressed leaf K and P in young apple trees.

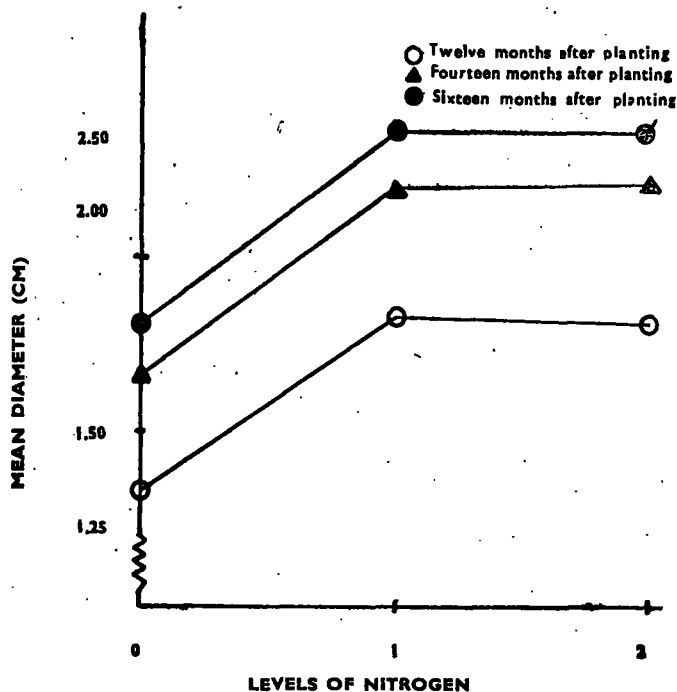


Fig. 1. Effect of three levels of nitrogen on growth

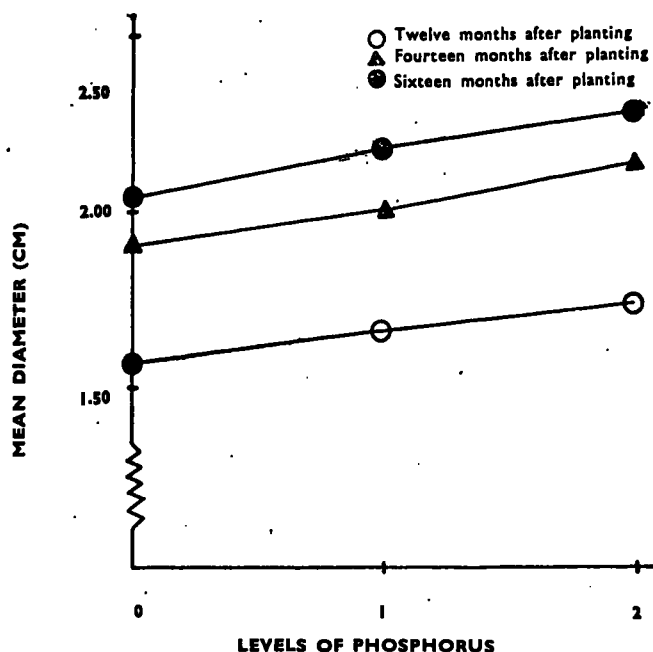


Fig. 2. Effect of three levels of phosphorus on growth

An examination of the responses to the NPK combinations reveals (Table 6) that the best growth of 2.66 cm was recorded in the $N_1P_2K_1$ plots, which amounted to a 50% increase in diameter over the $N_0P_0K_0$ plots. This indicates that no beneficial effects are likely to be obtained by using combinations with higher levels such as $N_1P_1K_2$, $N_1P_2K_2$ and $N_2P_2K_2$. An increase of 44% in growth over $N_0P_0K_0$ was recorded by the $N_1P_1K_1$ mixture as against an increase of 50% by $N_1P_2K_1$. Economic considerations of fertilizer use are however likely to support the use of the $N_1P_1K_1$ over the $N_1P_2K_1$ mixture. A NPK mixture is therefore necessary probably at the $N_1P_1K_1$ level, and the importance of magnesium has to be considered. Results shown in Table 5 reveal that the best growth of 2.77 cm was recorded in plots that received $N_1P_1K_1Mg_1$ which accounted for an increase of 23% over the plots that received the NPK mixture without magnesium. However, increasing magnesium from Mg_1 to Mg_2 level in the $N_1P_1K_1$ mixture, depressed growth by 8%.

TABLE 6

EFFECT OF INTERACTION BETWEEN LEVELS OF N, P, K AND Mg ON GROWTH AT THE END OF 16 MONTHS
MEAN DIAMETER (CM)

Treatments	Diameter (Mean of 30 plants)	% of lowest level in all nutrients
$N_0 P_0 K_0$	1.77	100
$N_1 P_1 K_0$	2.21	125
$N_1 P_2 K_0$	2.22	125
$N_1 P_1 K_1$	2.54	144
$N_2 P_2 K_1$	2.66	150
$N_1 P_1 K_2$	2.60	147
$N_1 P_2 K_2$	2.24	127
$N_2 P_2 K_2$	2.56	145
(Mean of 10 plants)		
$N_1P_1K_1Mg_0$	2.26	100
$N_1P_1K_1Mg_1$	2.77	123
$N_1P_1K_1Mg_2$	2.59	115

Application of ammonium sulphate, saphos phosphate, muriate of potash and epsom salt resulted in raising the leaf concentration of nitrogen, phosphorus, potassium and magnesium, respectively. This is in agreement with the findings of Shorrocks (1964). Moreover, the leaf levels of all nutrients under investigation, except potassium, are within the limits set by Bolle-Jones (1954a,b,c,) for leaf composition of healthy *H. brasiliensis*. The potassium content of leaves that received K at the highest level (K_2) is 1.065 as against the lowest limit of 1.10, for healthy plants. However, leaf nutrient concentration provides only a rough estimate of the nutritional status of trees (Guha, 1969). It is primarily controlled by nutrient supply (Steenbjerg & Jakobsen, 1963), but may be influenced by secondary external and internal factors (Smith, 1962), such as age and position (Bould, 1955; Mason, 1958), climate and pests and diseases (Boynton & Compton, 1945). All these factors should be taken into account when interpreting leaf analysis data.

Increasing the number of fertilizer applications per year from two to six gave an increase in growth but this was not significant at 5%. This finding is in agreement with the results observed with one-year old plants in the field (Silva, 1970).

CONCLUSION

The results of these experiments support the present practice of applying a complete NPK Mg mixture to plants in the seedling nursery. These studies indicate that the optimum level of fertilization for nursery plants is the total annual application of 6 oz per plant of a fertilizer mixture in the ratio of 4:6:5:2 of N, P_2O_5 , K_2O and MgO, respectively. Application of fertilizers in repeated small doses is unlikely to be more beneficial than less frequent application of correspondingly larger amounts. If there is any benefit from frequent applications it may be due to the greater efficiency in the recovery of fertilizer applied in small doses because of lower leaching losses. The elimination of waste by avoiding adverse application conditions should make it possible to reduce the frequency of fertilizer application.

ACKNOWLEDGEMENTS

The authors are deeply grateful to Dr O. S. Peries, Director, for valuable discussions and for the encouragement given; Mr. E. Bellis, Colombo Plan Consultant in Soils Chemistry, for his comments; Mr. Deepal Peiris for preparing the diagrams, and the Statistics Section for some analyses of the data.

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