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RESPONSE OF THE HIGH YIELDING *HEVEA* CLONE RRII 105 TO FERTILIZERS

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In an experiment to assess the fertilizer requirement during immature stage of *Hevea brasiliensis* clone RRII 105 laid out in an acidic soil of high organic carbon and low P and K status it was observed that 30, 30 and 20 kg/ha/year of N, P_2O_5 and K_2O respectively were sufficient for growth improvement. In the early tapping phase highest yield was observed when 60, 30 and 40 kg/ha/year of the nutrients were applied. Though P build up was noticed in all the plots when it was applied, K and organic carbon contents were not influenced by the treatments. There was no influence of the treatments on leaf N and P status.

Key words: Fertilizers, Growth, *Hevea*, Nutrient status, Yield.

INTRODUCTION

Judicious nutrient management has long been considered essential for improving the growth and yield of rubber. Nutrient requirement of rubber is generally considered to be low as the earlier plantations were raised mostly in newly cleared forest soils rich in plant nutrients. Moreover legume ground covers are established along with rubber in the interspaces and are retained during the initial three to four years. Besides N fixation by these legumes, decaying ground covers also add large quantity of organic matter and nutrients to the soil. Rubber being a deciduous tree adds about seven to eight tonnes of litter and nutrients in the range of 94 to 130 kg N, 5 to 6 kg P, 22 to 25 kg K, 106 to 168 kg Ca and 17 to 33 kg Mg per hectare per year (Varghese *et al.*, 2001). Nutrient removal from the system is limited only through latex and wood. The existing rubber plantations are in the second or third cycle of planting and more and more marginal lands low or deficient in nutrients are brought under rubber cultivation. Hence nutrient management should be given adequate importance to sustain productivity at economic levels.

Although beneficial effect of fertilizer application on improving the growth of rubber was reported (George, 1964; Punnoose *et al.*, 1975) in most of the experiments, the response was confined to the early years of immaturity. No consistent yield response to fertilizer application was observed in many experiments (George, 1961; Pushpadas *et al.*, 1979). Clonal differences in the fertilizer requirement was also reported (Bolle-Jones and Ratnasingam, 1954; Shorrocks, 1965). At present more than 90 per cent of

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the new planting in India is with the clone RRII 105 which has an average yield of 2400 kg/ha/year. The present experiment was taken up to assess the fertilizer requirement of the clone RRII 105 from planting to the early tapping phase.

MATERIALS AND METHODS

The experiment was laid out at Kodumon estate, Adoor, Kerala, India in 1989 in RBD with three replications. The soil was Ustic Kanhaplohumults, high in organic carbon content (1.95 per cent) and low in available P (0.11 mg/100 g) and K (3.12 mg/100 g) with a mean pH of 4.7. The treatments were selected combinations of three levels of nitrogen (30, 60 and 90 kg/ha/year), two levels of phosphorus (30 and 60 kg/ha/year), two levels of potassium (20 and 40 kg/ha/year) and a no fertilizer control.

Polybag plants of clone RRII 105 were planted at a spacing of 4.9 m x 4.9 m in 1989. The gross plot size was 24 trees with a net plot size of 8 trees. Urea, rock phosphate and muriate of potash were applied as the sources of N, P and K respectively in two equal splits during April-May and September-October every year. *Mucuna bracteata* was maintained as cover crop during the immature phase. All the cultural operations were carried out as per the recommendation of the Rubber Board.

Soil and leaf samples (0-30 cm) were collected periodically during the course of the experiment and analyzed for pH (1:2.5), organic carbon by Walkley and Black's method (Jackson, 1973), available P (Bray and Kurtz, 1945), available K (Morgan, 1941) and exchangeable Mg (Vogel, 1969). Leaf samples were analysed for nitrogen, phosphorus and potassium (Piper, 1966). Girth was recorded annually. The trees came to tapping in 1997. The tapping system followed was 1/2S d/4. From 2001 onwards, trees were stimulated (six rounds annually by panel application) with ethephone 2.5 per cent. Six stimulations were given annually as panel application. Latex yield was recorded once in every month from 1998 onwards and annual yield (in terms of g/tree/tap) was worked out. The data were subjected to analysis of variance.

RESULTS

Growth

The effect of different combinations of N, P and K fertilizers on growth of rubber from third to the thirteenth year of planting is shown in Table 1. There was no significant difference between treatments during the third year of planting. Significant difference in girth was observed during the fourth to tenth year from planting. During this period, the treatment which received N, P_2O_5 and K_2O at the rates of 30:30:20 and 30:30:40 showed superiority. Another treatment which improved the girth significantly was that which received the nutrients at the rate of 60:30:40 kg/ha/year. The treatment 30:60:20 also registered significantly superior girth during 6th year onwards when compared to control. Some of the other treatments though showed higher girth during certain years, were not consistent. After the tenth year of planting, there was no significant difference between treatments with respect to girth.

Girth increment from third to fifth year of planting followed more or less the same trend as girth (Table 2). The treatments which received N, P_2O_5 and K_2O at the rate

Table 1. **Effect of different combinations of N, P_2O_5 and K_2O on girth (cm)**

Treatment	Year after planting										
N P K	3	4	5	6	7	8	9	10	11	12	13
0:0:0	8.16	13.56	20.51	28.8	35.16	44.98	51.00	52.77	58.24	61.48	61.46
30:30:20	9.87	17.06	26.11	34.78	41.20	50.50	55.96	58.60	62.36	65.28	66.32
30:30:40	9.47	16.07	25.00	33.93	40.32	49.58	53.51	56.31	61.78	64.58	65.46
30:60:20	9.17	15.33	24.46	32.27	39.57	50.23	55.51	58.51	64.19	67.57	66.98
30:60:40	8.83	14.17	22.37	30.68	37.33	46.61	47.89	55.15	58.71	62.37	63.38
60:30:20	8.95	14.37	22.18	30.31	36.45	45.53	51.19	54.84	59.82	62.92	63.88
60:30:40	9.50	16.21	26.15	36.08	42.83	52.85	56.00	60.11	65.41	68.82	70.10
60:60:20	9.24	15.56	23.94	31.76	38.11	47.67	52.26	55.91	60.68	65.22	65.87
60:60:40	9.39	14.91	22.88	31.97	38.84	48.98	54.48	58.98	60.46	63.56	70.23
90:30:20	9.72	15.44	23.51	32.25	38.91	48.75	53.90	56.32	60.31	63.18	64.57
90:30:40	9.10	14.04	22.19	30.65	37.32	47.49	53.09	56.02	60.27	63.95	64.48
90:60:20	9.48	14.79	23.11	31.08	37.60	47.32	51.09	56.06	61.16	62.07	63.97
90:60:40	8.79	13.82	21.42	29.73	36.26	46.44	51.64	54.97	59.31	63.44	64.36
SE	0.38	0.70	1.05	1.04	1.17	1.12	1.36	1.40	1.48	1.54	2.13
CD ($P \leq 0.05$)	NS	2.03	3.05	3.05	3.42	3.27	3.98	4.08	NS	NS	NS

of 30:30:20, 30:30:40, 30:60:20 and 60:30:40 kg/ha/year were comparable and significantly superior to the control. From fifth to eighth year of planting, only the treatment 60:30:40 kg/ha/year was significantly superior in girth increment when compared with the control. From eighth year onwards, there was no significant difference between treatments in girth increment.

Table 2. **Effect of different combinations of N, P_2O_5 and K_2O on girth increment (cm)**

Treatment	Year after planting		
N P K	3-5	5-8	8-15
0:0:0	12.35	24.50	20.27
30:30:20	16.24	24.39	21.57
30:30:40	15.53	24.58	20.01
30:60:20	15.29	25.77	21.94
30:60:40	13.54	24.24	21.62
60:30:20	13.23	23.35	22.98
60:30:40	16.65	26.70	22.80
60:60:20	14.70	23.73	23.39
60:60:40	13.49	26.09	26.68
90:30:20	13.79	25.24	21.49
90:30:40	13.09	25.30	22.69
90:60:20	13.63	24.21	20.85
90:60:40	12.63	25.02	22.19
SE	0.83	0.61	1.76
CD ($P \leq 0.05$)	2.42	1.78	NS

Latex yield

The effect of the fertilizer on latex yield is presented in Table 3. Tapping was initiated in the eighth year from planting and the data on yield from the second to the fifth year of tapping showed significant superiority of the treatment combination of N, P_2O_5 and K_2O at 60:30:40 kg/ha/year. The combination of 60:60:40 also registered significantly higher yield during second to fourth year of tapping. There was significantly higher yield in the plots which received the treatment combination of 90:30:40 during the fifth year of tapping, under the influence of stimulation. However during the sixth year of tapping there was no significant difference between the treatments.

Soil nutrient status

Application of the different treatment combinations did not influence the organic carbon content of the soil (Table 4). Compared to the pre-treatment soil, there was a general increase in the organic carbon content in all the treatments. Significant im-

Table 3. **Effect of different combinations of N, P_2O_5 and K_2O on latex yield (gram/tree/tapping)**

Treatment (N P K)	Yield					
	1998-99	1999-2000	2000-01	2001-02	2002-03	Mean
0:0:0	46.08	46.74	52.55	66.69	71.87	56.79
30:30:20	55.21	54.52	53.90	67.65	66.84	59.62
30:30:40	59.32	63.32	55.01	84.87	69.28	66.36
30:60:20	55.95	63.56	58.83	83.58	74.93	67.37
30:60:40	49.58	47.71	52.13	68.39	71.33	57.83
60:30:20	46.91	57.42	52.25	60.18	71.54	57.66
60:30:40	74.36	73.17	80.17	98.57	82.01	81.66
60:60:20	48.45	56.63	52.99	51.75	62.69	54.50
60:60:40	64.46	63.85	68.20	73.18	72.19	68.38
90:30:20	47.83	50.61	55.87	75.41	86.61	63.27
90:30:40	51.96	60.16	60.85	90.45	90.92	70.87
90:60:20	56.12	61.00	55.48	68.31	68.41	61.86
90:60:40	44.92	53.29	56.70	84.60	79.96	63.89
SE	5.43	4.98	4.64	7.84	9.52	
CD ($P \leq 0.05$)	15.86	14.52	13.56	22.90	NS	

provement in available P status was observed in the treatments which received P at the higher level (60 kg/ha/year). There was no significant difference in the soil K status during the first and second samplings. The K status was slightly lower than the pre-treatment value in most of the treatments. During third sampling (2000), the soil K status in the treatments which received the nutrients at the levels 60:30:40, 60:60:40, 90:30:40, 90:60:20 and 90:60:40 kg/ ha/ year was significantly higher than that of the control. However, except in the treatment combination 90:30:40, the soil K content was in the lower range (<5mg/100g). Soil Mg status and pH were not influenced by the different treatments (data not presented).

Table 4. **Effect of different combinations of N, P_2O_5 and K_2O on soil nutrient status**

Treatment	Organic Carbon (%)			Available P (mg/100g)			Available K (mg/ 100g)		
N P K	1995	1997	2000	1995	1997	2000	1995	1997	2000
0:0:0	1.99	2.28	2.16	0.69	0.83	0.48	3.43	1.92	2.97
30:30:20	2.26	2.57	2.38	0.96	1.07	3.32	3.88	2.75	3.14
30:30:40	2.40	2.40	2.57	1.25	1.30	1.72	3.71	2.25	3.37
30:60:20	1.80	2.62	2.38	2.13	3.17	11.70	5.00	2.63	3.33
30:60:40	2.17	2.40	2.25	1.63	3.77	6.25	4.13	2.85	3.64
60:30:20	2.19	2.02	2.12	1.70	1.60	2.71	2.75	2.13	3.10
60:30:40	2.28	2.47	2.38	2.04	1.10	8.35	4.29	2.59	4.09
60:60:20	2.13	2.32	2.19	1.71	2.30	7.70	3.13	2.71	3.65
60:60:40	1.95	2.16	2.53	2.13	3.17	13.20	2.73	3.39	4.29
90:30:20	2.20	2.33	2.42	2.13	1.63	2.52	2.05	3.79	3.14
90:30:40	2.11	2.66	2.09	1.21	0.85	1.77	2.14	2.34	5.08
90:60:20	2.11	2.66	2.54	2.13	3.20	7.81	3.34	2.29	4.40
90:60:40	1.64	2.05	2.60	2.46	2.50	10.42	3.25	2.59	4.46
SE	0.21	0.22	0.13	0.47	0.30	1.85	0.78	0.45	0.31
CD ($P \leq 0.05$)	NS	NS	NS	1.36	0.86	5.40	NS	NS	0.90

Yield

Most of the fertilizer experiments conducted earlier were using clones with low productivity and there was no consistent response to fertilizer application during the first four to five years after tapping (Pushpadas *et al.*, 1979). Watson (1989) suggested that fertilizer application could be suspended for four years after the commencement of tapping and thereafter only sufficient N should be applied to replace that lost through latex. In the present experiment, the treatment 60:30:40 gave the maximum yield before commencement of stimulation (Table 3). This indicates that high yielding clones may require more nutrients to sustain productivity. Higher girth was also observed in this treatment and this might have contributed to the higher yield. Significant positive correlation was observed between girth and yield during third and fourth year of tapping (Table 6). Before stimulation, increasing the dose of N from 60 to 90 kg/ha/year had no additional benefit. When the trees were stimulated, the fertilizer combination of 90:30:40 was observed to support significantly higher yield. This indicates higher N requirement under stimulation.

Table 6. **Correlation analyses**

Year	Variables	r
1995	Soil organic C vs leaf N	0.04
	Soil available P vs leaf P	-0.30
	Soil available K vs leaf K	0.18
1997	Soil organic C vs leaf N	0.02
	Soil available P vs leaf P	-0.14
	Soil available K vs leaf K	0.31 *
1999	Girth vs yield	0.71 **
2000	Soil organic C vs leaf N	0.15
	Soil available P vs leaf P	-0.38 *
	Soil available K vs leaf K	-0.03
	Girth vs yield	0.65 **
2001	Soil organic C vs yield	0.70
	Soil available P vs yield	0.10
	Soil available K vs yield	0.28
	Girth vs yield	0.09

* Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

Even though the soil P status was low, increasing the level of P from 30 to 60 kg/ha/year did not have any additional beneficial effect on yield. Significant build up of P occurred in P applied plots and hence the lower dose might be sufficient. Lack of response in yield to P application has already been reported (Guha, 1969; Sivanadyan *et al.*, 1972). However, Punnoose *et al.* (1975) observed an increasing trend in yield with P application when soil P was low to medium. Pushparajah (1969) reported that the main requirements for mature rubber, which received fertilizer during the immaturity period, were N and K and best effects were obtained when both were applied together. Hence the data indicate that increasing the dose of N and K from the present general recommendation of 30 kg/ha/year each to 60 and 40 kg/ha/year respectively may enhance the yield of clone RRII 105 in the types of soil in which this experiment was conducted.

Soil nutrient status

There was a general increase in the organic carbon content of the soil over the years. Large quantity of organic matter is recycled through the decaying legume cover during the initial years. From fifth year onwards, annual defoliation also adds organic matter to the soil. This contributes to the general improvement in the organic carbon content of the soil. The rate of degradation of organic matter in rubber plantations is slow due to the closed canopy of rubber and hence the organic carbon status is generally high in rubber plantations (Krishnakumar and Potty 1992). Application of different combinations of N, P_2O_5 and K_2O did not influence the organic carbon content of the soil (Table 4). Available P content of the soil was generally higher in the P applied treatments. Compared to nitrogen and potassium, loss of applied P from the soil is less and annual application of P results in a build up. The increased P status in the unfertilized treatment might be due to the P addition through leguminous ground cover. The K status was slightly lower compared to the pre-treatment soil in most of the treatments. Large quantity of K released from the decaying legume cover and leaf litter failed to bring an appreciable improvement in soil K status. Even in the treatments which received K_2O at 40 kg/ha/year there was no appreciable improvement in the soil K status. In the unfertilized treatment, soil K status remained low indicating the need for continued K supplement for rubber.

Leaf nutrient status

In rubber plantations, large quantity of N is recycled through decaying legume cover, and litter fall. The trees appeared to be able to maintain the leaf N status even in the unfertilized treatment from this N pool and the leaf N content in the control was higher than that of most of the other treatments in all the sampling. Leaf N status was not correlated with soil organic carbon content.

As in the case of N, leaf P status also was not significantly influenced by the different treatments and was generally higher in control plants. Rubber is a surface feeder with greatest root proliferation in the surface 0-7.5 cm soil layer (Soong, 1976). This particularly helps the trees to acquire P which is a non mobile nutrient. The higher leaf P status in the control indicate the ability of the trees to acquire this element without external application even when the soil available P was low (< 1mg/100g). Under conditions of low soil P availability, plants improve their P acquisition through several adaptations like enhanced secretion of acid phosphatase from roots, higher activities of PEP carboxylase and malate dehydrogenase, enzymes involved in the biosynthesis of organic acids in the roots, lower rhizosphere pH and higher fine root production (Gaume *et al.*, 2001; Jessy, 2004). No positive correlation was observed between leaf P status and soil available P content during any of the samplings (Table 6). Pushparajah *et al.* (1979) also observed lack of correlation between soil and leaf P and suggested that rubber trees could be meeting their P requirement from the organic forms.

The leaf K status was generally lower in the control treatment. Soil K status also was low in the unfertilized treatment and this indicates that trees need continued supplement of K. Positive correlation was observed between leaf K status and soil available K content only during 1997.

The study suggests that application of N, P_2O_5 and K_2O at the rate of 30,30 and 20 kg/ha/year is sufficient for improving the growth of plants during pre-tapping phase. During the early tapping phase, application of higher levels of N and K_2O was found to be beneficial.

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