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RESPONSE OF RUBBER (*HEVEA BRASILIENSIS*) TO NPK FERTILIZERS IN THE LOWER BRAHMAPUTRA VALLEY ZONE OF ASSAM

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A field experiment was conducted to study the response of rubber to NPK fertilizers in the Lower Brahamaputra Valley Zone (LBVZ) of Assam. The treatments consisted of four levels of N and three levels each of P and K in factorial randomized block design. Nitrogen and K significantly influenced the girth and girth increment. Optimum level of N, P and K for achieving good growth in immature phase and improving the soil fertility was found to be 50:20:40 kg/ha/year. The interactions of N, P and K were non significant. Nitrogen, P and K application significantly improved the rubber yield. Positive linear response to N, P and K on rubber yield was observed. The highest yield was recorded by 60:40:40kg NPK/ha/year. Continuous application of N, P and K fertilizers improved the fertility status of the soil.

Keywords: Dry rubber yield, Fertilizer response, *Hevea brasiliensis*, North East India, Soil fertility

INTRODUCTION

In India, the traditional rubber growing tract extends from Kanayakumari district in Tamil Nadu to Dakshin Kannada district in Karnataka. Rubber cultivation is now extended to north-eastern part of India where the soil is highly depleted and deficient in nutrients due to the shifting cultivation practised over several years. The situation is further aggravated by the routine practice of cutting and removal of thatch grass (Laskar *et al.*, 1983). Leaching loss of essential cations due to high rainfall also results in low nutrient status of the soil (Talukdar, 1997). The soils of Assam are reported to be poor in nutrient status (Krishankumar and Potty, 1989; Singh *et al.*, 1999, 2000, 2001, 2002 and 2005).

Improvement in growth and reduction in the gestation period of rubber grown in poor and marginal soils through the application of chemical fertilizers has been reported by many workers (Dijkman 1951; Owen *et al.*, 1957; Punnoose *et al.*, 1975). Proper soil and nutrient management is highly essential for achieving optimum growth and yield, especially in marginal and depleted soils. Current practice is to follow the general fertilizer recommendation of 35: 35: 35 kg N, P and K/ha/year for mature rubber. Studies on the response of rubber to fertilizer application in the soils of Assam are few. There was a felt need to study the response of rubber to chemical fertilizers under the agroclimatic conditions of Assam for revising /modifying the general fertilizer

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recommendation (35:35:35 kg N, P, K /ha/ year for mature rubber) and arriving at a site-specific fertilizer recommendation package for this region.

MATERIALS AND METHODS

The experiment was conducted in a grower's field at Nayakgaon, Kokrajhar, Assam about 240 km away from Guwahati. The terrain was plain and texture of the soil was clay loam. Nine-month-old plants of RRII 105 raised in polythene bags were transplanted to the field during 1987. The experiment was laid out in factorial randomized block design with 36 treatment combinations and two replications with a gross plot size of 36 and net of 16 plants. The treatments consisted of four levels of N (0, 20, 40 and 60 kg/ha), three levels of P_2O_5 (0, 20 and 40 kg/ha) and three levels of K_2O (0, 20 and 40 kg/ha). The initial soil properties for 0-30 and 30-60 cm depths are presented in Table 1. The soil was extremely acidic in pH, medium in organic carbon status, very low in available P and low in available K.

Fertilizers were applied twice in a year, during April/May (pre-monsoon) and September–October (post-monsoon). Nitrogen was supplied as urea and P as water soluble P (single super phosphate) during the first two years and as water insoluble P (rock phosphate) in the subsequent years and K as muriate of potash. Routine cultural operations were followed as per the recommendations of Rubber Board. Soil samples were collected from the experimental field prior to the commencement of the experiment and at the end of the 15th year and analyzed for OC, available P, K, Ca and Mg as per the standard procedure outlined by Jackson (1973). Leaf samples were collected as per standard procedure (Shorrocks, 1962) during the 15th year and analyzed for the total nutrient concentration (Piper, 1966). Girth of the plants was recorded at a height of 150 cm from the bud union. Tapping was commenced during 1996 and regular yield recording was carried out from 1997 for six consecutive years up to 2003. Dry rubber content (%) and dry rubber yield (g/t/t) were recorded monthly once for six consecutive years. The tapping system adopted was S/2d3 6d/7 and total tapping days varied from 71-75 days in a year.

Table 1. **Pre-treatment soil nutrient status**

Parameter	Depth (cm)	
	0-30	30-60
pH	4.37	4.38
Organic carbon (%)	0.98	0.94
Available P (kg/ha)	1.80	1.60
Available K (kg/ha)	37.00	43.00
Available Ca (kg/ha)	455.20	433.40
Available Mg (kg/ha)	188.40	180.80

From the mean yield, the annual yield (kg/ha) was estimated by multiplying with plant population (420 trees/ha), respective per cent tappability and number of tapping days (72 days). Unlike the conventional formula for calculating the annual yield, the per cent tappability of respective treatments was used to delineate the treatment effect. All the data were subjected to analysis of variance and the quadratic response curve of graded levels of N, P and K on girth was plotted (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of NPK fertilizers on growth

Girth data from 8th to 15th year of experiment is presented in Table 2. Interaction of N x P, N x K, P x K and N x P x K on girth and girth increment during this stage of growth was non-significant. Hence, the response of individual nutrients is

Table 2. **Effect of N, P and K fertilizers on girth (cm)**

	Nutrient level (kg/ha/year)							
	8	9	10	11	12	13	14	15
Nitrogen								
0	39.5	45.4	47.0	49.4	51.3	52.2	53.6	55.5
20	44.1	48.6	50.1	51.8	53.5	55.0	56.2	57.9
40	47.1	50.2	51.6	53.6	55.3	56.7	57.8	59.6
60	46.5	50.6	51.9	53.7	55.4	56.7	57.8	59.5
CD (P = 0.05)	1.98	1.45	1.47	1.50	1.55	1.39	1.39	1.44
Phosphorus								
0	44.1	48.8	50.2	52.3	54.3	55.3	56.6	58.5
20	43.9	47.6	49.3	51.1	52.7	54.3	55.4	57.2
40	45.2	49.5	51.0	52.9	54.7	55.8	57.0	58.7
CD (P = 0.05)	NS	1.26	1.28	1.28	1.36	1.20	1.19	1.25
Potassium								
0	43.7	47.8	49.3	51.4	53.1	54.3	55.5	57.3
20	45.9	48.8	50.3	52.2	54.5	55.5	56.7	58.5
40	46.3	49.6	50.9	52.8	54.4	55.6	57.0	58.6
CD (P = 0.05)	1.68	1.26	1.28	1.28	1.36	1.20	1.19	1.25

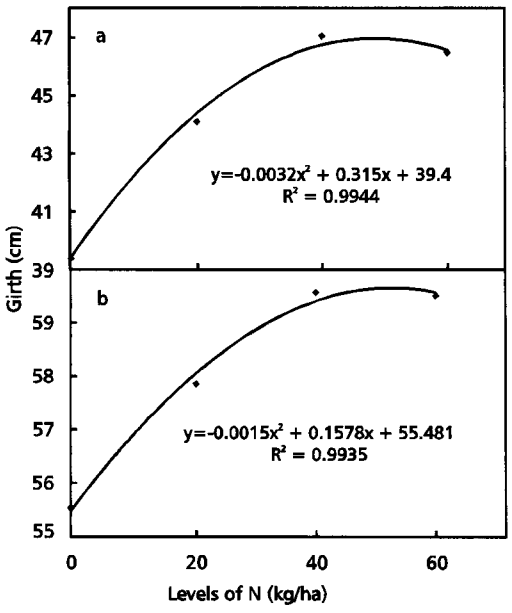

Fig. 1. Effect of graded levels of nitrogen on the girth of plants at (a) 8th year; (b) 15th year

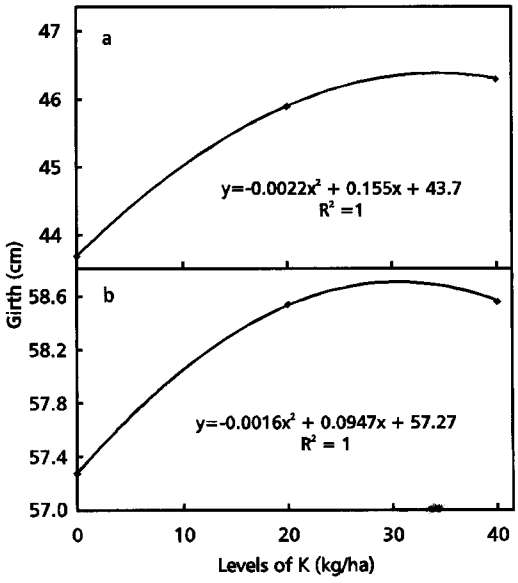

Fig. 2. Effect of graded levels of potassium on the girth of plants at (a) 8th year; (b) 15th year

discussed independently. Significant difference in girth was recorded with graded levels of N. Positive and significant response to N application was recorded in all the years. The response was more pronounced at 40 kg N/ha rather than the highest dose of 60 kg/ha. During the 8th year, the highest girth was recorded with 40 kg N/ha, and at the 60 kg N/ha level, the girth was slightly reduced. Similar results on growth response was reported earlier by Owen *et al.* (1957), Punnoose *et al.* (1975), Krishnakumar and Potty (1989), Mandal *et al.* (2000; 2003), and Singh *et al.* (1999; 2000; 2001; 2002; 2005).

Application of graded levels of P did not show any positive influence on girth from 8th year to 15th year of the experiment and the girth increment over this period was also not influenced by the graded levels of P.

Significant positive response to K application was recorded throughout the period of study. During the 15th year, positive and significant response to K application was

Table 3. **Effect of N, P and K fertilizers on yield (g/t/t)**

	Nutrient level (kg/ha/year)						Mean yield of six years (g/t/t)	Estimated yield (kg/ha/year)
	2	3	4	5	6	7		
Nitrogen								
0	32.2	31.7	28.5	28.2	24.9	29.7	29.2	883.6
20	35.4	41.2	35.9	35.1	33.7	38.5	36.6	1107.4
40	40.3	53.8	41.2	44.4	42.5	51.7	45.6	1379.9
60	36.3	67.1	52.8	58.7	58.5	68.6	57.0	1724.6
CD (P = 0.05)	2.90	5.8	4.25	6.1	2.91	2.83	3.12	88.90
Phosphorus								
0	40.7	44.2	36.7	38.5	35.0	40.8	39.5	1193.9
20	33.4	49.2	39.7	44.3	39.8	48.0	42.2	1276.4
40	33.3	54.1	42.4	45.1	45.0	52.8	45.5	1375.0
CD (P = 0.05)	2.49	5.01	3.68	5.51	2.29	2.45	2.52	76.20
Potassium								
0	34.0	45.1	36.8	38.9	37.7	44.5	39.7	1201.7
20	36.0	49.3	40.5	44.1	39.6	47.2	42.8	1284.3
40	38.2	53.2	41.9	44.8	42.3	49.9	45.4	1362.6
CD (P = 0.05)	2.49	5.01	3.68	5.51	2.29	2.45	2.52	76.20
Interactions								
CD (P = 0.05)								
N x P	4.99	NS	NS	NS	NS	NS	NS	NS
N x K	4.99	NS	NS	NS	NS	NS	NS	NS
P x K	4.32	NS	NS	NS	NS	NS	NS	NS
N x P x K	8.64	NS	NS	NS	NS	NS	NS	NS

Table 4. **Effect of N, P and K fertilizers on dry rubber content (%)**

	Nutrient level (kg/ha/year)						Mean drc of
	2	3	4	5	6	7	six years (%)
Nitrogen							
0	28.7	30.3	30.0	31.5	33.0	32.1	30.3
20	30.6	31.6	31.6	32.6	34.4	34.2	32.4
40	31.2	32.2	32.3	32.1	34.9	34.7	32.9
60	30.7	33.4	33.0	32.5	35.9	35.5	33.5
CD (P = 0.05)	1.23	1.27	1.28	0.75	0.86	1.19	1.04
Phosphorus							
0	30.0	31.1	30.2	32.0	33.6	33.5	30.9
20	30.2	32.2	31.4	32.3	34.8	34.7	32.5
40	30.6	33.1	32.3	32.2	35.2	35.0	33.0
CD (P = 0.05)	NS	1.06	1.10	NS	0.72	1.02	0.91
Potassium							
0	30.5	30.9	30.6	32.0	34.0	33.5	31.1
20	30.8	32.4	31.8	32.3	34.5	34.6	32.5
40	30.1	33.1	32.9	32.2	35.1	35.2	33.1
CD (P=0.05)	NS	1.06	1.06	NS	NS	1.02	0.91
Interaction							
N x P	2.13	NS	NS	NS	NS	NS	NS
N x K	2.13	NS	NS	NS	NS	NS	NS
P x K	1.84	NS	NS	NS	NS	NS	NS
N x P x K	3.69	NS	NS	NS	NS	NS	NS

recorded at 20 kg K_2O/ha/year and was on par with 40 kg K_2O/ha/year. Positive response to K application might be due to the low K status of the soil. Positive growth response to K application in soils with low K was reported from traditional as well as non-traditional regions (Singh *et al.*, 1999; Mandal *et al.*, 2003).

Quadratic response curve for graded doses N and K on the girth of plants during the 8th and 15th year was fitted and the equations are provided (Fig. 1 & 2). From the respective response equation, the optimum level of N and K for achieving the highest growth was calculated. Though levels of P did not show significant girth improvement over control, it improved the available P status of the soil. Based on the study, the fertilizer recommendation for achieving good growth for the region was found to be 50:20:40 kg/ha/year.

Effect of NPK fertilizers on yield

Influence of fertilizer application on dry rubber yield is presented in Table 3. Here also, the interaction effect is non-significant throughout the experiment period except during second year and hence the effect of individual nutrients is discussed independently. Significant positive response

Table 5. **Effect of N, P and K fertilizers on available nutrient status of the surface soil at 15th year**

Nutrient level (kg/ha)	pH	OC (%)	Available nutrients (kg/ha)	
			P	K
Nitrogen				
0	4.76	1.53	7.6	197.6
20	4.78	1.78	11.8	219.9
40	4.81	1.99	17.7	239.7
60	4.82	2.37	33.4	258.3
CD (P = 0.05)	0.021	0.21	2.86	0.82
Phosphorus				
0	4.81	1.81	8.3	220.6
20	4.83	1.93	16.1	229.8
40	4.84	2.01	28.6	235.9
CD (P = 0.05)	0.018	0.18	2.48	0.71
Potassium				
0	4.86	1.91	10.6	224.9
20	4.79	1.93	18.9	229.6
40	4.78	2.05	23.6	232.1
CD (P = 0.05)	0.018	0.18	2.48	0.71
Interactions				
CD (P = 0.05) for N x P	0.04	0.36	4.70	1.38
N x K	0.04	0.36	4.70	1.38
P x K	0.03	0.31	4.26	1.16
N x P x K	0.06	0.62	8.52	2.32

Table 6. **Effect of N, P and K fertilizers on available nutrient status of the subsurface soil at 15th year**

Nutrient status (kg/ha)	pH	OC (%)	Available nutrients (kg/ha)	
			P	K
Nitrogen				
0	4.74	1.51	6.9	146.1
20	4.76	1.72	10.1	170.7
40	4.77	1.84	16.4	195.1
60	4.79	1.95	30.5	209.7
CD (P = 0.05)	NS	0.36	2.78	11.45
Phosphorus				
0	4.73	1.61	6.2	169.1
20	4.71	1.73	14.6	193.1
40	4.80	1.96	26.9	204.9
CD (P = 0.05)	NS	0.30	2.36	10.2
Potassium				
0	4.81	1.59	8.5	171.4
20	4.75	1.71	14.3	184.9
40	4.71	1.98	22.9	205.9
CD (P = 0.05)	NS	0.30	2.36	10.17
Interactions				
CD (P = 0.05) for N x P	0.01	0.49	8.0	22.40
N x K	0.01	0.49	8.06	22.40
P x K	0.01	0.34	6.72	19.60
N x P x K	0.02	0.67	13.44	39.40

of N application on dry rubber content and yield was recorded over the years. With increasing levels of N, yield was also increased and the highest mean yield of 57.0 g/t/t was recorded with 60 kg N/ha and the lowest yield of 29.2 g/t/t was recorded for control.

Application of P significantly enhanced the yield and the highest yield (45.5 g/t/t) was recorded under the treatment 40 kg P_2O_5/ha followed by 20 kg P_2O_5/ha (42.2 g/t/t). Compared to control, 6.91 and 15.17 per cent higher yield was recorded by 20 and 40 kg P_2O_5/ha, respectively. Similarly, volume of latex was also increased by P application. Similar results were also reported by Mandal *et al.* (2003) and Singh *et al.* (2005).

Significant yield improvement over control was recorded with the application of K from

the first year of tapping. For the first five years of tapping, 20 kg K_2O/ha/year recorded the highest yield. During the 6th and 7th year, 40 kg K_2O/ha/year recorded the highest yield. Mean yield also followed the same trend. Improvement in bark quality and dry rubber content with K application was reported by Pushparajah (1969) and Mohammed *et al.* (1975).

Annual yield was estimated based on the mean yield for the six years (Table 3). Positive and significant linear response to N, P and K was observed. The highest yield was recorded for 60 kg N, 40 kg P_2O_5 and 40 kg K_2O /ha/year.

The dry rubber content (Table 4) also increased with increasing levels of N and 33.5% increase was recorded under 60 kg N/ ha followed by 32.9% in 40 kg N/ha and 32.4% with 20 kg N/ha. The lowest dry rubber content of 30.3% was recorded under control. Similarly, positive response to P and K application on dry rubber content was recorded in certain years. The mean dry rubber content over six years also indicated significant positive response to levels of P and K.

Table 7. **Effect of N, P and K fertilizers on the leaf nutrient concentration**

Nutrient level (kg/ha)	Leaf nutrient status (%) N	P	K
Nitrogen			
0	3.01	0.22	1.06
20	3.29	0.25	1.15
40	3.48	0.28	1.23
60	3.79	0.30	1.39
CD (P = 0.05)	0.01	0.01	0.01
Phosphorus			
0	3.32	0.24	1.17
20	3.38	0.27	1.20
40	3.49	0.30	1.27
CD (P = 0.05)	0.01	0.01	0.01
Potassium			
0	3.34	0.25	1.16
20	3.39	0.28	1.18
40	3.45	0.30	1.29
CD (P = 0.05)	0.01	0.10	0.01
Interactions			
CD (P = 0.05) for N x P	0.02	NS	NS
N x K	0.02	NS	NS
P x K	0.02	NS	NS
N x P x K	0.04	NS	NS

Effect of NPK fertilizers on soil nutrient status

Effect of N, P and K fertilizer treatments for 15 years on the availability of nutrients in the soil is presented in Table 5 and 6. Marked improvement in the available nutrient status of the soil, particularly in the surface soil (Table 5) was observed due to fertilizer application. At the end of the 15th year of planting, organic carbon status was increased significantly from medium to high with increasing levels of NPK fertilizers. Similarly, available P and K status in soil was also improved significantly. The interaction effect was found to be significant influencing the balance of nutrients in the soil.

Effect of NPK fertilizers on leaf nutrient status

Leaf N, P and K concentrations were significantly influenced by the application of respective nutrients (Table 7). Application of 60 kg N/ha/year recorded significantly higher leaf N over control. Similarly, P application improved the P content of the leaf. Gradation in leaf K status with K application was also recorded. Interaction of N x P, N x K, P x K and N x P x K was significant for leaf N concentration.

CONCLUSION

Growth of rubber plants was significantly influenced by fertilizer application and the effect was statistically significant for N and K. Nitrogen significantly increased the girth over control and positive response was recorded for up to 40 kg N /ha/year. Similarly, positive response to K application was recorded for up to 20 kg/ha/year and the growth at 40 kg K_2O/ha/year was on par with 20 kg K_2O/ha/year. Phosphorus application did not influence the growth of plants. At the same time, improvement in the availability of P in soil was noticed with the application of P fertilizers. From the response function of graded levels of N and K on girth, optimum dose of N and K for achieving the highest growth was calculated. Based on the study, the fertilizer recommendation for young rubber for the region was found to be 50:20:40 kg/ha/year to be supplied through two equal splits.

The highest yield was recorded at the combination of 60:40:40 kg/ha/year of N, P_2O_5 and K_2O. Positive linear response to fertilizer application on dry rubber yield was recorded by N, P and K. The current recommendation of 35:35:35 kg/ha/year of N, P_2O_5 and K_2O for mature rubber is found to be too insufficient. Continuous application of N, P and K fertilizers was found to improve the fertility status of the soil. Based on the results of this experiment alone optimum dose of N, P, and K cannot be worked out, but the necessity to increase the dose is felt for improving the fertility status of the soil and for achieving better growth and yield.

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