Rate and Time of Fertiliser Application Influences Growth of Immature Rubber and Soil Fertility in Tripura

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Rate and time of NPK fertiliser application did not affect the growth of immature rubber in the first 3 years of a field study. However, from the fourth year, they had a significant effect on the girth of rubber plants and number of tappable plants. A decline in available K in surface soil even at the highest level of K application suggests K vulnerability of the rubber growing soils of northeastern India.

In India, the cultivation of natural rubber (*Hevea brasiliensis*) has generally been confined to a narrow tract in the southwest region located between 8^{0}N to 12^{0}N. But increased domestic rubber demand and the scarcity of land in the traditional rubber-growing area has led to farmer's cultivating rubber in non-traditional areas like in the northeastern (NE) region of India.

Nutrient requirements of rubber are likely to be higher in the NE region compared to the the traditional rubber-growing region as the majority of the soils in the NE region are degraded and poor in fertility due to shifting cultivation (Chowdhury et al., 2001, 2004; Krishnakumar and Potty, 1989a, 1989b, 1990). Moreover, rubber has a long gestation period of 7 years, and in the NE region, this period often gets increased by one more year due to abiotic stresses like low winter temperature, soil moisture deficit between January-March, hail storms, etc. Application of higher doses of NPK during early years was reported to reduce the immature period of rubber (Dijkman, 1951, Owen et al., 1957, Bolton, 1960). In the traditional rubber growing region, fertilisers are generally applied in two equal split doses (once in April/May and once in September/October) synchronizing with the two peak rainfall seasons (southwest and northeast monsoons) of this region. But in the NE region of India, only the southwest monsoon is active from June through September. This is followed by a cool period from October to November. Therefore, low soil moisture together with low air temperature after the post-monsoon fertiliser application often lead to poor absorption of nutrients and poor girthing of plants. The challenge therefore is to develop a fertiliser recommendation package that is relevant to the soil and climatic conditions of the NE region. The present field experiment was initiated in 2004 to optimise time and level of fertiliser application for young rubber grown in the NE state of Tripura.

The experiment was conducted in 2004 in a farmer's field at Amtali, Agartala (Latitude: 23^{0}45'N; Longitude: 91^{0}27') with clone RRIM 600 as the planting material. The experimental soil is an Alfisol with clay-loam texture. The trial was laid out in a factorial randomized block design with ten treatments and four replications. Each block had 25 gross plants with nine net plants. Growth and tappability of plants were recorded from the inner nine plants only to eliminate the border effect of other treatments.

Abbreviations and notes: K = potassium; N = nitrogen; P = phosphorus; SSP = single superphosphate.

Table 1. Recommended NPK rates (kg/ha) in different years of rubber growth.

	N	P_2O_5	K_2O
First year	14	14 (7)*	7
Second year	50	50 (25)	25
Third year	65	65	35
Fourth year	50	50	25
Fifth year	35	35	35

*Values in parentheses denote water soluble P_2O_5 (kg/ha) supplied through SSP

Table 2. Influence of rate and time of fertiliser application on mean girth* (cm) during late immature phase of rubber plantation.

Treatments	4th year	6th year	7th year
Control	18.3	32.1	39.8
50% RDF	21.6	36.2	43.7
100% RDF	24.5	41.4	47.5
150% RDF	21.7	39.2	46.5
50% RDF (two equal splits)	22.7	37.2	44.6
100% RDF (two equal splits)	26.1	42.2	49.1
150% RDF (two equal splits)	24.1	40.4	47.7
50% RDF (2/3:1/3 split)	22.2	38.0	45.8
100% RDF (2/3:1/3 split)	23.6	40.2	47.6
150% RDF (2/3:1/3 split)	24.2	41.3	48.6
Mean	22.9	38.8	46.2
CD (p = 0.05)	3.7	4.8	5.5

*Stem girth measured at 150 cm height from bud union; RDF = recommended dose of fertiliser, presently followed.

Treatments used in the experiment are detailed as follows:

A. Fertiliser levels (4)
   i. No fertiliser (control)
   ii. 50% of the recommended dose of fertiliser (RDF)
   iii. 100% RDF
   iv. 150% RDF

B. Timing of fertiliser application (3)
   i. Single application (pre-monsoon)
   ii. Two equal, split applications (pre- and post-monsoon)
   iii. 2/3rd during pre-monsoon and 1/3rd during post-monsoon.

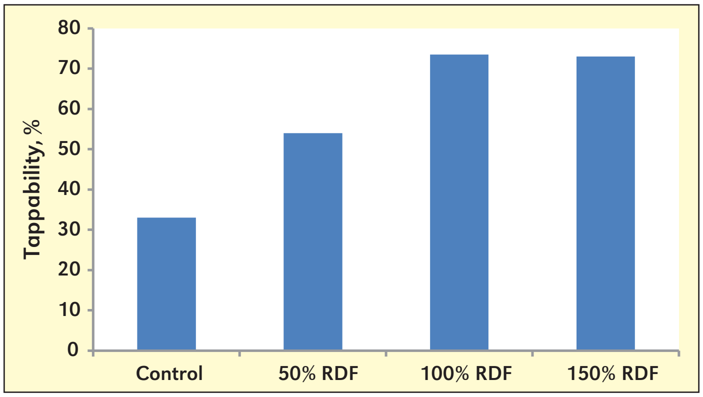

Figure 1. Influence of fertiliser rates on tappability of plants (end of 7th year).

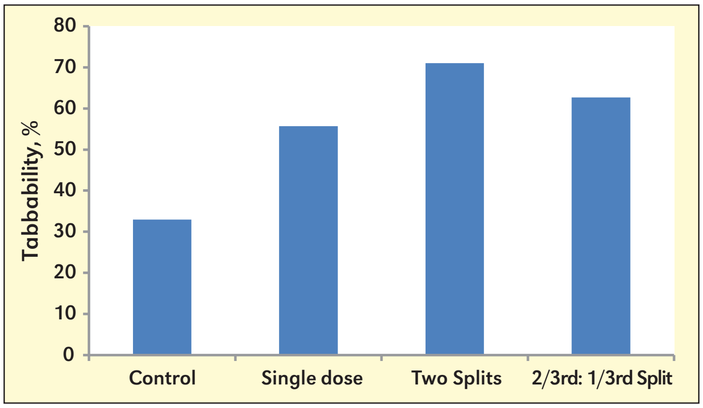

Figure 2. Effect of split fertiliser application on tappability of plants (end of 7th year).

The fertiliser rates used in the present experiment were recommended by Rubber Research Institute of India (RRII) and are shown in **Table 1**. Nitrogen was supplied as urea and potassium as muriate of potash. In the initial 2 years, 50% of the applied P was supplied using rock phosphate (citrate-soluble P) and the rest was applied using SSP (water-soluble P) for good root development and early establishment of plants. Routine culture operations were carried out following the recommendations of the RRII. For the first 4 years of rubber growth, fertiliser was applied over a circular band of about 30 to 75 cm width around the plant base. The applied fertiliser was slightly forked into the soil as practiced in the NE region while it was broadcasted in the subsequent years. Trunk diameters (girth) of the plants were measured from the bud union at a height of 25 cm for the initial 2 years and thereafter at a height of 150 cm. Tappability of plants was computed based on the percent of plants attaining trunk girth of 50 cm. Replicated soil samples were collected from the experimental area at depths of 0 to 30 cm and 30 to 60 cm prior to the commencement of the experiment. At the end of 4th and 6th years, soil samples were again collected from each plot and analyzed for pH, organic carbon (OC), available P, and available and non-exchangeable K following standard procedures (Baruah and Barthakur, 1997). At the end of the 4th and 6th years of plantation, leaf samples were also collected from each plot and analyzed for NPK content.

A view of a tapped, mature rubber plantation located in northeast India.

Growth of Plants

Growth data for the initial 3 years of plantation showed no significant difference in girth of the plants due to nutrient treatments. However, at the end of the 4th year, rubber plants responded significantly to the application of N, P, and K fertilizers **(Table 2)**. The girth difference between plants receiving NPK fertilisers and no fertiliser ranged from 3.9 to 9.3 cm. The recommended rate of NPK applied in two equal splits registered the highest average girth (49.1 cm) among all the treatments.

Influence of split fertiliser application on the growth of rubber was compared between two regimes, viz., regime I (April to September: Southwest monsoon period) and regime II (October to March: Post-monsoon cool period) **(Table 3)**. In regime I, fertiliser applied in a single dose or on the 2/3rd: 1/3rd basis contributed 74 to 77% towards the annual mean increment. The corresponding value for fertiliser applied in two equal splits was 68%. In regime II, fertiliser application in two equal splits contributed about

Table 3. Influence of split application of fertiliser on the growth of rubber.

Treatments	Annual mean girth increment, cm	% increment (April-Sept) Southwest monsoon	% increment (Oct-March) Cold period
Control	5.1	76 (3.87)	24 (1.23)
50% RDF	5.7	78 (4.45)	22 (1.25)
100% RDF	6.2	77 (4.77)	23 (1.43)
150% RDF	6.1	77 (4.69)	23 (1.41)
50% RDF (two equal splits)	5.8	69 (4.01)	31 (1.79)
100% RDF (two equal splits)	6.4	69 (4.41)	31 (1.99)
150% RDF (two equal splits)	6.2	67 (4.15)	33 (2.05)
50% RDF (2/3:1/3 split)	5.9	75 (4.42)	25 (1.47)
100%RDF (2/3:1/3 split)	6.2	74 (4.58)	26 (1.62)
150% RDF (2/3:1/3 split)	6.3	76 (4.78)	24 (1.52)
CD (p = 0.05)	0.9	(0.56)	(0.28)

Values in parentheses are girth increment in cm; RDF = recommended dose of fertiliser.

Table 4. Influence of rate and time of fertiliser application on nutrient content of rubber leaves.

Treatments	N, %		P, %		K, %	
	4th year	6th year	4th year	6th year	4th year	6th year
Control	2.67	2.71	0.16	0.17	0.83	0.86
50% RDF*	2.68	2.76	0.15	0.19	0.91	0.93
100% RDF	2.69	2.98	0.18	0.18	0.94	0.95
150% RDF	2.70	3.10	0.16	0.20	0.97	0.96
50% RDF (two equal splits)	2.82	2.90	0.20	0.21	0.96	1.02
100% RDF (two equal splits)	2.85	2.96	0.19	0.20	1.07	1.10
150% RDF (two equal splits)	2.87	2.98	0.18	0.22	1.04	1.10
50% RDF (2/3:1/3 split)	2.85	2.90	0.17	0.19	0.90	0.93
100%RDF (2/3:1/3 split)	2.80	2.92	0.16	0.21	0.92	1.05
150% RDF (2/3:1/3 split)	2.82	2.97	0.16	0.21	0.98	1.12
Mean	2.77	2.91	0.17	0.20	0.95	1.01
CD (p = 0.05)	ns	0.18	ns	ns	0.13	0.14

*RDF = recommended dose of fertilizer.

32% towards the annual mean growth of rubber, while the corresponding values for single fertiliser application and the 2/3rd: 1/3rd application (i.e. T_8-T_{10}) ranged between 23 and 26%. Because rubber is a tropical crop, it showed higher girthing during the southwest monsoon period (regime I) when favorable agro-climatic conditions prevailed. This period was the active growth period. During regime II, plant growth is retarded due to low winter temperature, soil moisture stress, and other abiotic factors. Thus, our experiment showed that the application of fertiliser at the right rate and at right time helped lessen the effect of growth-retarding factors and ensured higher girthing during non-favorable times of rubber growth.

Tappable Plants

A trunk girth of 50 cm is important for commercial exploitation of rubber plants. Therefore, the influence of fertiliser doses on rubber plants attaining tappable girth was evaluated **(Figures 1 and 2)**. At the end of the 6th year, tappable plants ranged from 0 to 18%, while at the end of the 7th year, these ranged from 33 to 84%. Among the fertiliser rates, highest tappability (71%) was obtained with the recommended dose of fertilisers **(Figure 1)**. Correspondingly, fertiliser applied in two equal splits helped the highest (71%) number of plants to attain tappable girth **(Figure 2)**. Higher tappability under two equal split applications may be due to better utilization of nutrients by plants, whereas a single application of NPK or application of higher doses before pre-monsoon might have lead to more losses of nutrients by leaching or by greater fixation in soils.

Leaf Nutrient Content

Leaf samples were analyzed for N, P, and K contents after 4 and 6 years of rubber plantation **(Table 4)**. The data revealed a significant improvement in N and K content of leaves due to fertiliser application. Critical level for leaf N for rubber is 3 to 3.5%. In the present case, leaf N varied from 2.7 to 3.1% with a mean value of 2.9%. The critical values for leaf K are 1 to 1.5%. After the 6th year of plantation, leaf K content ranged from 0.86 to 1.12% with a mean value of 1.01%. A significant improvement in leaf K values was observed with application of higher doses of K fertiliser. Also, this effect was more pronounced when K was applied in two equal splits. Increased leaf N and leaf K values for the plants in the treated plots suggested higher uptake of N and K resulting in higher girthing of plants over the control plot.

Soil fertility

Effect of different fertiliser treatments on soil fertility status

Table 5. Potassium balance in the experimental plots

Treatments	Applied K fertiliser, kg/ha	Initial values, kg/ha		After 4th year, kg/ha		After 6th year, kg/ha		After 4th year, Increase (+) or decrease (-)		After 6th year, Increase (+) or decrease (-)	
		I*	II*	I	II	I	II	I	II	I	II
Control	0	123	85	85	94	70	101	-38	9	-54	16
50% RDF**	66	114	87	76	101	65	110	-38	14	-49	22
100% RDF	133	131	98	74	116	72	141	-57	18	-60	43
150% RDF	199	129	110	105	90	72	125	-14	-20	-47	16
50% RDF (two equal splits)	66	124	85	81	94	72	128	-43	9	-52	42
100% RDF (two equal splits)	133	125	109	121	96	101	110	-4	-12	-25	1
150% RDF (two equal splits)	199	129	74	83	112	83	121	-46	38	-46	47
50% RDF (2/3:1/3 split)	66	125	110	94	108	78	119	-31	-2	-47	9
100%RDF (2/3:1/3 split)	133	131	75	81	101	69	137	-50	25	-61	62
150% RDF (2/3:1/3 split)	199	125	95	98	110	78	114	-27	14	-47	19
	Mean	126	93	90	102	76	120	-35	9	-49	28
	CD (p=0.05)	ns	ns	ns	ns	ns	ns	-	-	-	-

*I: 0 to 30 cm soil depth and II: 30 to 60 cm soil depth.
**RDF – Recommended dose of fertiliser.

was also evaluated. No significant improvement in OC content of soil was observed in surface and sub-surface soils due to fertiliser application (data not shown). Available P content in acid soils of Tripura is quite low. In the present study, a general soil analysis done prior to the start of the experiment showed poor available P status (1.1 to 2.7 kg/ha). After the 6th year of plantation, P values were only marginally improved (4.2 to 4.5 kg/ha) (data not shown). This might be due to higher P fixation in acid soils. Plant available K content of these soils **(Table 5)** varied from low to medium (i.e. critical values between 112 to 280 kg/ha), and these values were found to decrease over time particularly in the surface soil. At the end of the 6th year of plantation, no significant difference in available K was found among any of the treatments used in the study. The slow reduction in soil available K values in the surface soil could be attributed to higher K fixation capacity of these soils, leaching loss due to high rainfall, and percolation of K in soil profile as evident from the gradual increase in available soil K within the sub-surface layer **(Table 5)**. A net negative K balance of -49 kg/ha was observed in the surface (0 to 30 cm) soil over a period of 6 years **(Table 5)**, whereas accumulation of 28 kg/ha K occurred in the sub-surface (30 to 60 cm) soil. However, considering the amount of K application, it becomes quite evident that a substantial amount of K was either washed away or fixed. Therefore, K management in the rubber growing soils of Tripura calls for special attention.

Conclusion and future needs

Application of the recommended rates of NPK fertilizers in two equal splits increased girth and tappability of rubber trees. However, the recommended nutrient rates did not improve the native fertility of the experimental soil. In fact, they led to the depletion of K in the soil. More studies are needed to optimize nutrient rate and timing of fertilizer application to achieve the twin goals of productivity improvement and sustenance of soil fertility in rubber growing areas of Tripura.

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