EFFECT OF FERTILIZERS ON THE AVAILABILITY OF NUTRIENTS IN THE SOIL AND GROWTH AND YIELD OF MATURE RUBBER IN THE CENTRAL BRAHMAPUTRA VALLEY ZONE (CBVZ) OF ASSAM

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A field experiment in mature rubber was conducted in a grower's field at Rampur village, Borgang, Sonitpur, Assam about 300 km away from Guwahati, the capital of Assam to study the response of mature rubber to inorganic fertilizers under the agro-climatic condition of Central Brahmaputra Valley Zone (CBVZ) of Assam using the clone RRIM 600. Girth and girth increment of rubber were significantly influenced by higher doses of fertilizers. Optimum levels of N, P and K for achieving the highest girth in mature rubber and improving the soil fertility was found to be 60:30:45 kg ha^{-1} yr^{-1}. Similarly, application of N, P and K significantly improved the yield and dry rubber content (drc). The highest yield (g $t^{-1}t^{-1}$) and drc (%) was recorded with 60:30:45 kg ha^{-1} yr^{-1}. Continuous application of fertilizers improved the soil fertility status.

Keywords: Dry rubber yield, Fertilizer response, Girth, Leaf nutrient concentration, North East India, Soil fertility

In India, rubber is traditionally grown in south-western parts, mostly in the states of Kerala, Kanyakumari district of Tamil Nadu and southern districts of Karnataka. However, due to the increased demand for natural rubber and non-availability of land in the traditional regions, rubber cultivation is now extended to north-eastern part of India. Soil in the north-eastern region is highly depleted and deficient mostly due to shifting cultivation practiced over several years (Datta *et al.*, 2001) and leaching of cations under high rainfall (Talukdar, 1997). The poor nutrient status of rubber growing soils of Assam has also been reported by many workers (Krishnakumar and Potty, 1989; Singh, *et al.*, 1999; 2010; Mandal *et al.*, 2000 and Choudhury *et al.*, 2001). Poor soil fertility results in inadequate plant growth and crop yield in this region compared to

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the traditional rubber growing belt which warrants regular application of fertilizer to obtain optimum growth and yield of rubber and maintenance of the soil fertility (Krishnakumar and Potty, 1989). Improvement of 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). The present recommended dose of fertilizer for mature rubber in the north-eastern region is 35:35:35 NPK kg $ha^{-1}yr^{-1}$. Studies on the response of rubber to fertilizer application in the soils of Assam are few and similar studies in other parts of the region showed significant increase in yield with higher doses of fertilizers (Choudhury *et al.*, 2001). Hence, it was felt necessary to study the response of mature rubber to higher doses of chemical fertilizers under the agro climatic condition of CBVZ of Assam for arriving at suitable recommendation for the region.

Table 1. **Initial fertility status of the soil from the experimental site**

Parameter	Depth (cm)	
	0-30	30-60
pH	5.05	4.94
Organic carbon (g kg^{-1} soil)	9.2	8.0
Available P (mg kg^{-1} soil)	3.3	1.60
Available K (mg kg^{-1} soil)	45.0	77.5

The experiment was initiated in a grower's field at Rampur, Borgang, Sonitpur, Assam about 300 km away from Guwahati, Assam during 2001 in mature rubber plantation of RRIM 600. The experiment was laid out in randomized block design (RBD) with 15 treatments and three replications with gross plot size of 25 and net plot of 9 plants. The treatments were confounded combination of N, P and K

Table 2. **Effect of fertilizer treatments on mean girth and girth increment**

Treatment	Pre-treatment girth (cm)	Girth (cm)		Girth increment (cm)	
	2001	2006	2012	over 6 years	over 11 years
T1 (0:0:0)	60.7	66.1	71.5	5.4	10.8
T2 (0:0:15)	60.5	66.6	73.1	6.1	12.6
T3 (0:15:0)	55.4	60.7	68.0	5.3	12.6
T4 (15:0:0)	61.1	66.0	74.4	4.9	13.3
T5 (0:0:30)	59.4	65.1	74.1	5.8	14.8
T6 (0:30:0)	61.3	67.3	77.3	5.9	16.0
T7 (30:0:0)	62.6	68.9	79.8	6.3	17.2
T8 (15:15:15)	60.7	66.8	78.8	6.1	18.1
T9 (30:15:30)	63.4	70.8	83.6	7.3	20.0
T10 (30:30:30)	63.8	70.6	83.5	6.8	20.2
T11 (45:15:30)	65.1	72.0	86.5	6.9	21.4
T12 (45:30:45)	63.6	71.5	86.4	7.9	22.8
T13 (60:15:30)	64.4	71.7	87.3	7.3	23.0
T14 (60:30:30)	62.6	71. 6	88.9	9.0	25.8
T15 (60:30:45)	65.3	75.5	93.6	10.3	28.3
SE ±	2.4	2.5	2.6	1.71	2.07
CD (P=0.05)	NS	NS	NS	4.7	5.74

Table 3: **Effect of fertilizer treatments on mean annual yield, estimated yield and dry rubber content**

Treatment	Dry rubber yield (g $t^{-1}t^{-1}$)	Estimated yield (kg ha^{-1})	Dry rubber content (%)
T1 (0:0:0)	22.5	795	31.6
T2 (0:0:15)	24.3	860	31.9
T3 (0:15:0)	26.2	928	32.1
T4 (15:0:0)	29.3	1038	32.4
T5 (0:0:30)	31.6	1118	32.5
T6 (0:30:0)	34.3	1213	32.8
T7 (30:0:0)	36.6	1294	33.0
T8 (15:15:15)	38.8	1374	33.3
T9 (30:15:30)	42.2	1493	33.4
T10 (30:30:30)	45.6	1614	33.6
T11 (45:15:30)	48.3	1709	34.0
T12 (45:30:45)	52.1	1843	34.2
T13 (60:15:30)	56.1	1987	34.4
T14 (60:30:30)	60.4	2137	34.5
T15 (60:30:45)	66.0	2338	35.1
SE ±	1.16	41.01	0.09
CD (P=0.05)	3.19	113.58	0.12

levels ranging from 0 to 60 for N, 0 to 30 for P and 0 to 45 for K.

Pre-treatment soil samples at the depth of 0-30 cm and 30-60 cm were collected and analyzed for organic carbon (OC), available P and K and pH. The soil was acidic (Table 1), medium in OC and K, and low in available P. Fertilizers were applied every year in two splits, during May and September as per the treatment. Urea, rock phosphate and Muriate of potash (MOP) were used as the sources of N, P and K, respectively. Routine cultural operations were followed as per the recommendations of Rubber Board. Soil samples were collected from the experimental field at the end of 5th year (2005) and 12th year (2013) after commencement of the experiment and analyzed for pH, OC, available P and K as per standard procedure outlined by Jackson (1973). Girth of the plants was recorded twice in a year at the height of 150 cm from the bud union. Dry rubber content (DRC %) and dry rubber yield (g $t^{-1}t^{-1}$) was recorded once in a month for eleven consecutive years. The tapping system adopted were ½ S d/2 6d/7 and total tapping days varied from 100 to 105 days in a year. Annual yield (kg ha^{-1}) was estimated by multiplying the mean yield with plant population (350 trees ha^{-1}) and the average number of tapping days (101 days). All the data were subjected to standard methods of statistical analysis using Gomez and Gomez (1984).

Girth and girth increment data recorded from the experiment are presented in Table 2. During 2012, the highest girth was recorded with $N_{60}P_{30}K_{45}$ kg ha^{-1} yr^{-1} followed by $N_{60}P_{30}K_{30}$ kg ha^{-1} yr^{-1} and lowest with $N_0P_{15}K_0$ kg ha^{-1} yr^{-1}. Similar trend was observed in case of girth increment in the years 2002 and 2012. The girth increment over 11 years was significantly higher for $N_{60}P_{30}K_{45}$ treatment compared to that with control. Positive response of fertilizer application on the growth of plants was reported earlier (Choudhury *et al.*, 2001 a; Owen *et al.*, 1957; Krishnakumar and Potty, 1989; Mandal *et al.*, 2000; 2003 and Singh *et al.*, 1999; 2002; 2010). The positive response to NPK application might be due to the low fertility status of the soil.

With increasing levels of NPK, yield also increased and the highest mean yield over 11 years was recorded with $N_{60}P_{30}K_{45}$ kg ha^{-1} yr^{-1} followed by $N_{60}P_{30}K_{30}$ kg ha^{-1} yr^{-1} and the lowest with control (Table 3). Mandal *et al.* (2003; 2013), Singh *et al.* (2010) and Pushparajah *et al.* (1969) also reported positive response of NPK fertilizers on yield.

Table 4. **Effect of fertilizer treatments on the nutrient status of the surface (0-30cm) soil**

Treatment	OC (g kg^{-1})		Av. P (mg kg^{-1})		Av. K (mg kg^{-1})		pH	
	2005	2013	2005	2013	2005	2013	2005	2013
T1 (0:0:0)	8.6	7.9	5.2	7.0	61.0	81.0	5.22	5.05
T2 (0:0:15)	9.7	10.7	5.3	7.2	67.0	88.0	5.23	5.08
T3 (0:15:0)	9.9	8.8	5.8	8.1	62.0	83.0	5.31	5.10
T4 (15:0:0)	10.2	11.2	6.8	7.5	66.0	84.0	5.32	4.88
T5 (0:0:30)	10.5	10.8	7.2	7.7	71.0	90.0	5.39	4.91
T6 (0:30:0)	10.6	11.1	7.5	8.7	70.0	86.0	5.44	4.99
T7 (30:0:0)	10.7	11.5	7.9	7.8	72.0	88.0	5.48	4.87
T8 (15:15:15)	10.8	11.7	8.2	8.5	76.0	93.0	5.53	4.93
T9 (30:15:30)	11.0	12.1	8.6	8.6	79.0	95.0	5.56	4.97
T10 (30:30:30)	11.2	12.1	8.8	9.0	82.0	98.0	5.59	5.12
T11 (45:15:30)	11.8	13.1	9.1	8.9	83.0	98.0	5.60	5.20
T12 (45:30:45)	12.2	13.5	9.3	9.5	81.0	101.0	5.61	5.18
T13 (60:15:30)	12.6	13.8	9.8	9.9	82.0	103.0	5.62	5.06
T14 (60:30:30)	12.9	14.1	10.4	11.2	86.0	106.0	5.63	5.13
T15 (60:30:45)	13.2	14.5	11.2	12.5	91.0	119.0	5.64	5.31
SE ±	0.16	0.29	0.12	0.30	0.90	2.70	0.019	0.025
CD (P=0.05)	0.33	0.83	0.25	0.86	1.84	7.80	0.04	0.07

Annual yield was calculated based on the mean yield of 11 years (Table 3). The highest estimated yield was recorded for $N_{60}P_{30}K_{45}$ followed by $N_{60}P_{30}K_{30}$ and the lowest for $N_0P_0K_0$. The dry rubber content (Table 3) also increased with increasing levels of NPK. The highest increase in dry rubber content was recorded with $N_{60}P_{30}K_{45}$ and the lowest with control ($N_0P_0K_0$). Positive effect of NPK applications on dry rubber content was reported by Pushparajah *et al.* (1969).

Effect of fertilizer treatments on the nutrient status of the soil at both the depths are presented in Table 4 and 5, respectively. Marked improvement in the available nutrient status of the soil particularly in the surface soil (Table 4) was observed due to fertilizer application. With increasing levels of fertilizer, significant improvement in available nutrient content of soil was observed at the end of 5th and 12th year. Similar result was reported by Mandal *et al.* (2013) from the fertilizer experiment with modern clones conducted at Tripura.

From the study, it has been observed that the highest yield was obtained in the treatment, $N_{60}P_{30}$ KA5. Positive linear response to N, P and K fertilizer application on dry rubber yield was recorded. Continuous application of N, P and K fertilizers was found to improve the fertility status of the soil. The current recommendation of 35:35:35 kg ha^{-1} yr^{-1} of N, P_2O_5 and K_2O for mature rubber is found to be insufficient for good growth, yield and maintenance of soil fertility. Hence, an annual fertilizer dose of 60:30:45 N:P_2O_5:K_2O kg ha^{-1} is to be considered for mature rubber in CBVZ.

Table 5. **Effect of fertilizer treatments on the nutrient status of subsurface (30-60 cm) soil**

Treatment	O C (g kg^{-1})		Av. P (mg kg^{-1})		Av. K (mg kg^{-1})		pH	
	2005	2013	2005	2013	2005	2013	2005	2013
T1 (0:0:0)	8.3	7.8	4.0	4.7	62.0	83.0	5.31	5.10
T2 (0:0:15)	8.5	9.5	4.4	5.0	69.0	89.5	5.31	5.11
T3 (0:15:0)	8.7	9.6	5.3	6.0	63.0	85.0	5.32	5.21
T4 (15:0:0)	8.9	9.9	6.3	7.1	68.0	85.5	5.33	5.00
T5 (0:0:30)	9.2	10.2	6.5	7.5	73.0	92.1	5.35	5.02
T6 (0:30:0)	9.5	10.6	6.9	7.7	72.0	87.3	5.37	5.07
T7 (30:0:0)	9.9	11.0	7.2	8.0	74.0	89.3	5.37	4.95
T8 (15:15:15)	10.1	11.2	7.4	8.6	78.0	95.0	5.41	5.00
T9 (30:15:30)	10.6	11.5	7.8	8.9	81.0	96.5	5.45	5.02
T10 (30:30:30)	10.9	11.9	8.1	9.3	83.0	99.3	5.48	5.16
T11 (45:15:30)	11.2	12.1	8.2	9.5	84.0	99.0	5.51	5.26
T12 (45:30:45)	11.4	12.3	8.5	9.7	83.0	102.5	5.64	5.22
T13 (60:15:30)	11.6	12.5	8.8	9.9	83.0	105.0	5.67	5.12
T14 (60:30:30)	11.8	12.8	9.5	10.5	87.0	106.8	5.70	5.21
T15 (60:30:45)	11.9	13.0	10.2	10.9	95.0	120.1	5.75	5.37
SE ±	0.18	0.018	0.14	0.15	0.89	2.81	0.018	0.024
CD (P=0.05)	0.52	0.052	0.41	0.43	1.83	7.78	0.048	0.070

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