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Nutritional Requirement of *Hevea*: II. Effect of N, P and K on Dry Matter Yield, Nutrient Content and Uptake of Nutrients by Rubber Seedlings in Assam

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ABSTRACT

The influence of N, P and K application on dry matter yield, nutrient content, uptake of nutrients, apparent nutrient recovery (ANR) and per cent yield response (PYR) by rubber seedlings (*Hevea brasiliensis*) under the Assam condition were studied for two consecutive years. Four levels of N (0, 166, 333 & 500 kg N ha^{-1}) and three levels of K (0, 62.5 and 125 kg K_2O ha^{-1}) and their combinations were applied with three replications. The design was R.B.D. The results showed that dry matter yield of rubber seedlings was significantly increased due to N application particularly N @ 333 kg ha^{-1} (23.6 ton ha^{-1}). A positive increase in yield was noticed for P and K. Highest yield was recorded under the treatment combination N_{333} P_{250} kg ha^{-1}. Application of N, P and K significantly increased their content in plants and uptake of nutrients as well. ANR (141.47 %) and PYR (121.27 %) was highest when nitrogen was applied @ 333 kg N ha^{-1} in comparison to control plots. Application of higher doses of P and K showed better response both for ANR and PYR. In all the cases PYR was found positive except for P (125 kg P_2O_5 ha^{-1}) indicating lower requirement of P than that of N and K during seedling nursery stage. Application of N, P and K showed improvement of available nutrient status of soil, which may subsequently, increase the growth and biomass yield of the seedlings compared to control plots.

Key words: *Hevea* seedlings, NPK fertilizers, Dry matter yield, Nutrient content, Uptake, Apparent Nutrient Recovery, per cent Yield Response and Soil characteristics.

INTRODUCTION

The cultivation of *Hevea* was traditionally confined to narrow tract in the South-West of India mostly in the state of Kerala. Due to limited land resources in the traditional rubber growing regions together with domestic demand of natural rubber, cultivation of rubber plantation has been extended in North Eastern part of India, which is considered as non-traditional region of rubber. The soils of this region are poor in nutrient status, which necessitates higher inputs of fertilizers, particularly N during immature phase of cultivation (Krishnakumar and Potty, 1989). The fertilization of rubber usually varies according to the age of the plants. Manuring of rubber plants at its various stages of growth *viz.*: nursery, immature and mature phases are done based on soil and leaf analysis. The object of manuring the seedling nursery is to produce maximum number of vigorous and healthy seedlings from unit area, which subsequently will be ready for budding with in shortest period of time. Though some work on nutritional requirement of *Hevea* in nursery was carried out in traditional region (Abdul Kalam and Punnoose, 1975; Punnoose, 1976) no work in this line has so far been reported from this region.

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In continuation of our studies on nutritional requirement of rubber in non-traditional rubber growing tract (Singh *et al.*, 1999; Mandal *et al.*, 2000; Singh *et al.*, 2000), the influence of N, P and K application on dry matter yield, nutrient content, uptake of nutrients, apparent nutrient recovery (ANR) and per cent yield response (PYR) by rubber seedlings (*Hevea brasiliensis*) under Assam condition are now being investigated.

MATERIALS AND METHODS

The experiment was carried out at the Sarutari Research Farm of Regional Research Station, Guwahati, Assam during the years 1997-98 and 1998-99 with rubber seedlings (*Hevea brasiliensis*). The area is situated at an elevation of 50 m msl and receives a mean annual rainfall of 1540 mm. The results of pre-treatment analyses of the soil in the site are presented in Table 1. The soil was sandy clay loam in nature and acidic in reaction with pH 4.9-5.2. Organic carbon content in medium range (9.1 g kg^{-1}), low in available P (8.4 kg ha^{-1}) and available K (109.2 kg ha^{-1}) and high in available Ca (710.08 kg ha^{-1}) and Mg (230.72 kg ha^{-1}). The experiment was laid out in a factorial Randomized Block Design (RBD) having thirty-six treatment combinations and three replications with gross plot size of forty-eight sq. meter (48) with (20) rubber seedlings. The treatments consisted of four levels of N (0, 166, 333 & 500 kg N ha^{-1}), three levels of P (0, 125 & 250 kg P_2O_5 ha^{-1}) and three levels of K (0, 62.5 and 125 kg K_2O ha^{-1}). Fertilizers were applied (half dose of nitrogen with full doses of phosphorus and potassium) during the month of October after establishing the seedlings in the seedling nursery. The remaining half dose of nitrogen was applied during March/April after sufficient moisture in the soil. Nitrogen was supplied as urea and phosphorus as (water soluble phosphorus) single super phosphate and potassium was applied as muraite of potash (KCl). Routine cultural operations were carried out following the recommendation of the Rubber Research Institute of India. Pre-treatment and post-treatment girth and height were recorded. At the end of the experiment, plant were uprooted and biomass yield of the plants (root, shoot and leaves) were recorded. Then plants were dried in oven at 55°C for constant weight to get dry biomass. The N, P and K contents of the plants were determined from the dried samples by digesting with di-acid mixture (HNO_3: $HClO_4$ :: 4 : 1) following standard analytical procedures (Jackson, 1973). The Apparent Nutrient Recovery (ANR) and Per cent Yield Response (PYR) were calculated as following:

$$\text{ANR (\%)} = \frac{[\text{Nutrient uptake by treatment (kg ha}^{-1})] - [\text{Nutrient uptake in control (kg ha}^{-1})]}{\text{Nutrient applied (kg ha}^{-1})} \times 100$$

$$\text{PYR} = \frac{\text{Treatment yields (kg ha}^{-1}) - \text{Control yields (kg ha}^{-1})}{\text{Control yield (kg ha}^{-1})} \times 100$$

Table 1: *Pre-treatment soil analysis report of the site*

Depth (cm)	O.C. (g kg^{-1})	Available nutrients (kg ha^{-1})				
		p	K	Ca	Mg	Soil pH
0-30	10.9	13.66	128.8	822.08	257.60	4.9
30-60	7.2	3.14	89.6	598.08	203.84	5.2
Mean	9.1	8.40	109.2	710.08	230.72	5.1

Statistical analysis of the nutrient data was done following the methods described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of N, P and K on dry matter yield

There was significant increase in dry matter yield of *Hevea* seedlings over control by N application (Table 2). However, response to nitrogen was more pronounced at the 333 kg N ha^{-1} levels beyond which a decreasing trend was observed with highest doses of N application (500 kg N ha^{-1}). It was reported that rubber seedlings showed a significant growth response towards N application (Hardjono, 1981; Singh *et al.*, 2000). Application of P and K fertilizers did not show any significant increase in dry matter yield. However, response of immature

Table 2: *Effect of NPK on dry matter yield and nutrient content of Hevea seedlings and post-harvest soil characteristics*

Treatments (kg ha^{-1})	Dry matter yield	Available nutrient status in soil						Nutrient content in plants (%)		
		O.C. (g kg^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})				
	(t ha^{-1})	A	B	A	B	A	B	N	P	K
Nitrogen (N)										
0.0 (Control)	7.98	11.8	8.6	17.69	3.81	189.28	186.14	3.22	0.27	1.18
166	14.56	12.9	11.3	17.92	5.38	234.98	224.45	3.50	0.30	1.27
333	21.64	14.3	12.9	18.37	7.17	327.04	294.78	3.69	0.32	1.38
500	20.02	15.3	14.3	18.82	8.96	385.06	352.35	3.99	0.34	1.51
S.E.m±	1.50	0.12	0.05	0.06	0.09	1.9	0.49	0.005	0.0046	0.0046
C.D. (P = .05)	4.50	0.34	1.4	0.16	0.22	5.31	1.37	0.014	0.012	0.013
Phosphorous (P_2O_5)										
0.0 (Control)	15.25	13.1	11.0	14.34	4.93	255.81	245.81	3.53	0.28	1.29
125	14.27	13.6	11.8	19.26	6.27	274.85	260.51	3.59	0.31	1.32
250	16.88	14.1	12.5	21.06	7.84	321.66	286.72	3.69	0.34	1.39
S.E.m+	1.20	0.10	0.50	0.05	0.07	1.64	0.43	0.004	0.0039	0.004
C.D. (P = 0.05)	NS	0.30	1.20	0.13	0.20	4.59	1.19	0.012	0.01	0.011
Potassium (K_2O)										
0.0 (Control)	14.86	13.4	11.5	17.92	5.82	270.82	255.84	3.55	0.29	1.30
62.5	15.82	13.6	11.8	18.14	6.27	280.22	264.77	3.60	0.31	1.30
125	16.11	13.8	12.0	18.59	6.72	301.06	272.83	3.65	0.33	1.37
S.E.m±	1.20	0.10	0.50	0.05	0.07	1.64	0.43	0.004	0.0039	0.004
C.D. (P = 0.05)	NS	0.30	NS	0.13	0.20	4.59	1.19	0.012	0.01	0.011
C.D. (P = 0.05) for										
NP/NK	6.80	NS	NS	NS	0.40	9.18	2.46	0.024	NS	0.022
	(2.39)	(0.25)	(0.99)	(0.10)	(0.13)	(3.27)	(0.85)	(0.009)	(0.008)	(0.008)
PK	5.90	NS	NS	NS	0.68	16.12	4.48	0.044	NS	NS
	(4.14)	(0.40)	(1.70)	(0.18)	0.24)	(5.68)	(1.48)	(0.016)	(0.014)	(0.014)

rubber towards application of P & K were also reported by Singh *et al.* (1999), Mandal *et al.* (2000) and Singh *et al.* (2000). The average increase in dry matter yield over control were 48.87, 121.26 and 104.7 per cent with 166, 333 and 500 kg N ha^{-1} respectively while these values were 6.47 and 8.41 per cent in case of 62.5 and 125 kg K_2O ha^{-1}. The effect of P application on dry matter yield was not significant. Interactions among the nutrients were non-significant.

Effect of N, P and K on Nitrogen content and their uptake

The nitrogen content of seedlings increased progressively with incremental doses of N. The uptake of nitrogen by rubber seedlings also increased significantly (Table 2 and 3) with incremental doses of N only upto 333 kg ha^{-1} level. The application of N in *Hevea* seedlings significantly increased the content and uptake of P and K. The mean of N uptake (Table 3) under different treatments significantly increased with the application of N alone as well as in association with P and K. It was also observed that the application of highest doses of N (500 kg N ha^{-1}) with or without P and K decreased the dry matter yield. Therefore, response of nitrogen was confined mainly to 333 kg N ha^{-1} level of application. The interaction effect of N, P and K was significant and maximum uptake value was recorded under N_{333} P_{250} $K_{62.5}$ kg ha^{-1} (880.3 kg ha^{-1}) followed by N_{333} P_{250} K_{125} kg ha^{-1} (876.6 kg ha^{-1}) and minimum was in $N_0P_0K_0$ (control) is 22.22 ton ha^{-1} (Table 3).

Effects of N, P and K on Phosphorus content and their uptake

Addition of P fertilizers increased the P content of rubber seedlings significantly. Application of N and K further enhanced the P content of plants significantly. This rise in P content might be due to increase in available soil P status or due to synergistic effect when applied in combination with N and K.

Addition of P alone significantly increased its uptake by *Hevea* seedlings from 43.1 to 56.6 kg ha^{-1} whereas, when applied in combination with N, its values was increased significantly from 25.2 to 69.8 kg ha^{-1} and in case of K the values increased from 46.5 to 54.4 kg ha^{-1}. The interaction effect of N × P and P × K on uptake was significant and maximum P uptake value was recorded under N_{333} P_{250} K_{135} kg ha^{-1} (83.1 kg ha^{-1}) followed by N_{333} P_{250} K 62.5 kg ha^{-1} (82.6 kg ha^{-1}) and minimum was in $N_0P_0K_0$ (17.8 kg ha^{-1}).

Effect of N, P and K on Potassium content and their uptake

The application of K increased its contents significantly over control (Table 2). The average increase in K- content (%) over control were 2.31 & 5.38 per cent with 62.5 & 125 kg K_2O ha^{-1} while these values were 7.63, 16.95 & 27.97 per cent when applied along with 166, 333 & 500 kg N ha^{-1}, respectively and in case of P these were 2.33 & 7.75 per cent with 125 & 250 kg P_2O_5 ha^{-1}, respectively.

The addition of K significantly increased its uptake by plants from 207.1 to 228.3 kg ha^{-1} whereas N increased it significantly from 109 to 298.9 kg ha^{-1} and in case of P it increased from 197.1 to 235.2 kg ha^{-1} (Table 3). The interaction effect of N, P, NK, PK and NPK was significant and maximum K uptake value was recorded under the combination of N_{333} P_{250} K_{125} kg ha^{-1} (342.9 kg ha^{-1}) followed by the N_{333} P_{250} $K_{62.5}$ kg ha^{-1} (339.8 kg ha^{-1}) and minimum was in control plot ($N_0P_0K_0$) is 114.2 kg ha^{-1}.

Effect of N, P and K on Apparent Nutrient Recovery (%)

Apparent Nutrient Recovery (ANR) is shown in Fig 1. When nitrogen is applied alone, maximum recovery was observed under the treatment 3.33 kg N ha^{-1} (141.47 per cent) and recovery was decreased with increasing doses of nitrogen (500 kg N ha^{-1}). Apparent Nitrogen recovery at 333 kg N ha^{-1} was more effective than it's highest level (500 kg N ha^{-1}). The recovery of N was further increased when applied in association with highest level of K (125 kg K_2O ha^{-1}). Application of Phosphorus

Table 3: *Interaction effect of N, P and K application on their uptake by the rubber seedlings*

Nitrogen levels (kg ha^{-1})	P_2O_5 (control) Potassium levels (kg ha^{-1})			Mean of NP	P_2O_5 (125 kg ha^{-1}) Potassium levels (kg ha^{-1})			Mean of NP	P_2O_5 (250 kg ha^{-1}) Potassium levels (kg ha^{-1})			Mean of NP	Mean of N
	0.0	62.5	125.0		0.0	62.5	125.0		0.0	62.5	125.0		
N uptake (kg ha^{-1})													
Control	222.7	271.2	295.8	263.2	291.0	295.2	315.2	300.5	310.1	263.6	395.0	322.9	295.2
166	417.4	460.1	438.1	438.5	489.0	502.9	414.3	502.1	432.5	407.1	587.9	509.2	483.2
333	758.3	771.1	739.9	756.4	774.5	781.7	778.2	778.1	800.4	880.3	876.6	852.4	766.3
500	647.5	669.7	725.7	680.9	726.9	741.4	723.2	730.5	805.4	726.0	876.3	802.6	738.0
Mean of PK	511.5	543.0	549.9	P_0=534.8	570.4	580.3	582.7	P_{120}=577.8	612.1	569.3	684.0	P_{250}=621.5	
Mean of K	K_0 = 564.6, K_{625} = 565.9 and K_{125} = 605.3												
CD (P = 0.05)	N = 15.5, P/K = 13.5, NP = 26.9, NK = 26.9, PK = 23.3, and NPK = 46.6												
P uptake (kg ha^{-1})													
Control	17.8	21.2	23.4	20.8	22.7	25.7	27.6	25.3	26.9	26.0	36.2	29.7	25.2
166	31.9	37.5	38.1	35.8	39.1	42.8	46.6	42.8	46.6	37.5	55.6	46.6	41.7
333	56.6	63.5	62.5	60.8	63.7	71.5	73.8	69.6	71.4	82.6	83.1	79.0	69.8
500	48.8	53.5	61.9	54.7	62.1	66.5	65.3	64.6	70.2	64.3	78.4	71.0	63.4
Mean of PK	38.8	43.9	46.5	P_0=43.1	46.9	51.6	53.3	P_{125}=50.6	53.8	52.6	63.3	P_{250}=56.6	
Mean of K	K_0 = 46.5, K_{625} = 49.4 and K_{125} = 54.4												
CD (P = 0.05)	N = 2.4, P/K = 2.1, NP = 4.2, NK = NS, PK = 3.6, and NPK = NS												
K uptake (kg ha^{-1})													
Control	82.9	97.4	107.9	96.1	104.6	107.3	118.3	110.0	114.2	101.9	147.4	121.2	109.0
166	145.6	165.0	161.3	157.3	171.0	179.1	186.1	178.7	195.1	150.6	219.7	188.5	174.8
333	274.8	287.3	276.2	279.4	282.2	291.1	293.1	288.8	302.8	339.8	342.9	328.5	298.9
500	237.1	252.1	278.3	255.8	272.9	281.3	277.9	277.3	302.3	274.5	331.0	302.6	278.6
Mean of PK	187.1	200.5	205.9	P_0=197.1	207.7	214.7	218.8	P_{125}=213.7	118.6	216.7	260.3	P_{250}=235.2	
Mean of K	K_0 = 207.1, K_{625} = 210.6 and K_{125} = 228.3												
CD (P = 0.05)	N = 6.2, P/K = 5.4, NP = 10.9, NK = 10.9, NK = 10.9, PK = 9.4, and NPK = 18.8												

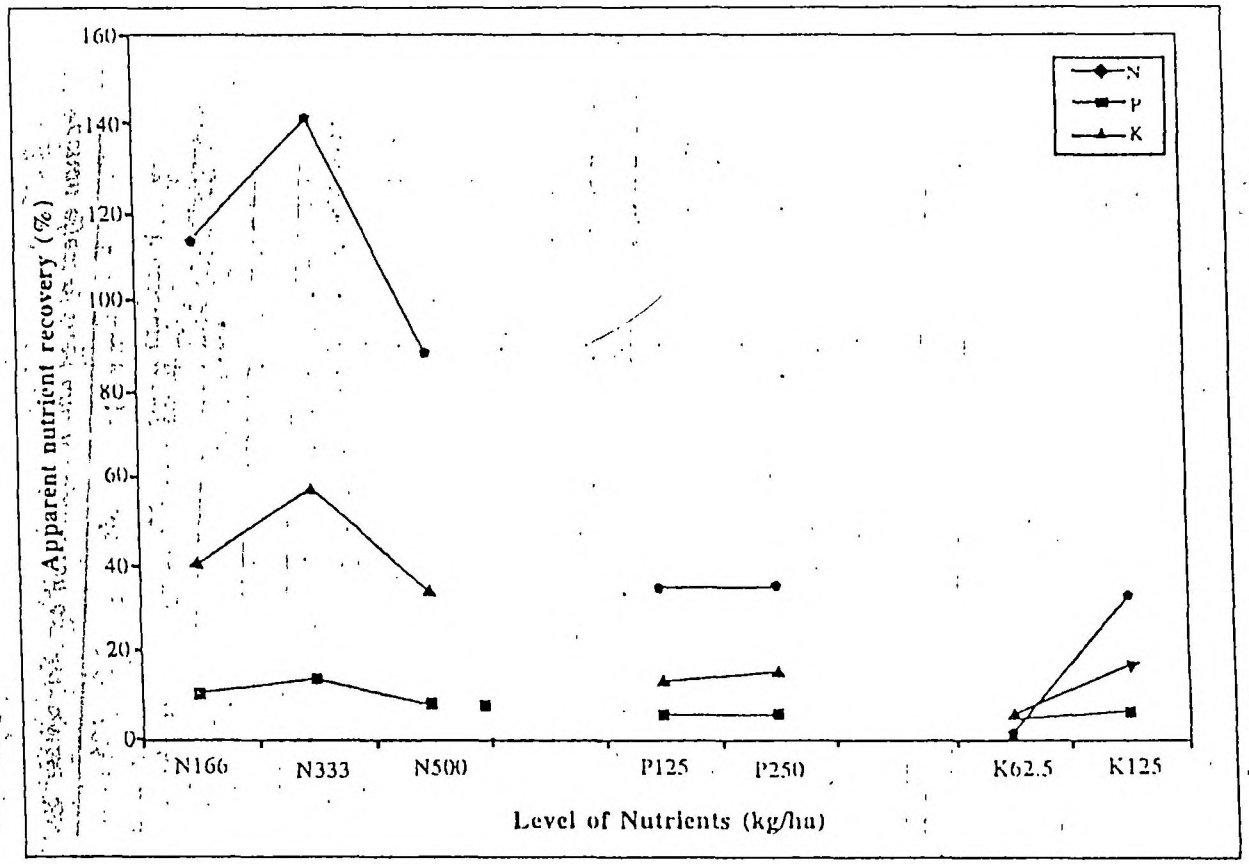

Fig. 1: *Effect of N, P and K on Apparent Nutrient Recovery (%) of Hevea in Seedling Nursery*

decrease the Apparent Phosphorus Recovery (APR) with increasing levels of P_2O_5 ha^{-1} (6.0 per cent). Application of 125 kg K_2O ha^{-1} showed better Apparent Potassium Recovery (AKR) (16.96) per cent) than 62.5 kg K_2O ha^{-1} (5.60 per cent). AKR was highest when it was applied along with nitrogen and showed synergistic effect with N & P. In all the cases ANR was found increasing trend except the highest done of N (500 kg ha^{-1}) and P (250 kg P_2O_5 ha^{-1}). Highest ANR was recorded with the combination N_{333} P_{125} (54.81 percent). Similar results in the green gram crop (*Vigna mungo*) have been reported (Pattanayak *et al.*, 2000).

Effects of N, P and K on Percent Response (PYR)

PYR was shown in Fig. 2 Maximum PYR of Nitrogen was observed under the treatment of 333 kg N ha^{-1} (121.27%) followed by N 500 kg ha^{-1} (104.70%) and minimum was in N 166 kg ha^{-1} (48.88%). Application of 125 kg P_2O_5 ha^{-1} showed a negative yield response (–6.43%) which was increased to 10.69% at the levels of 250 kg P_2O_5 ha^{-1}. Application of Potassium increased the percent yield response of K with increasing doses of K. It was maximum in 125 kg K_2O ha^{-1} (8.41%) followed by 62.5 kg K_2O ha^{-1} (6.46%). In all the cases, PYR were found positive except when lower dose of P (125 kg P_2O_5 ha^{-1}) was applied, indicating the relatively lower requirement of P than N and K for *Hevea* seedlings. A similar result in case of Fertilizer Use Efficiency (FUE) was reported earlier by Singh *et al.* (2000).

Effects of N, P and K on Soil Characteristics

The soil characteristics of the post harvest soils i.e. organic carbon content (g kg^{-1}),

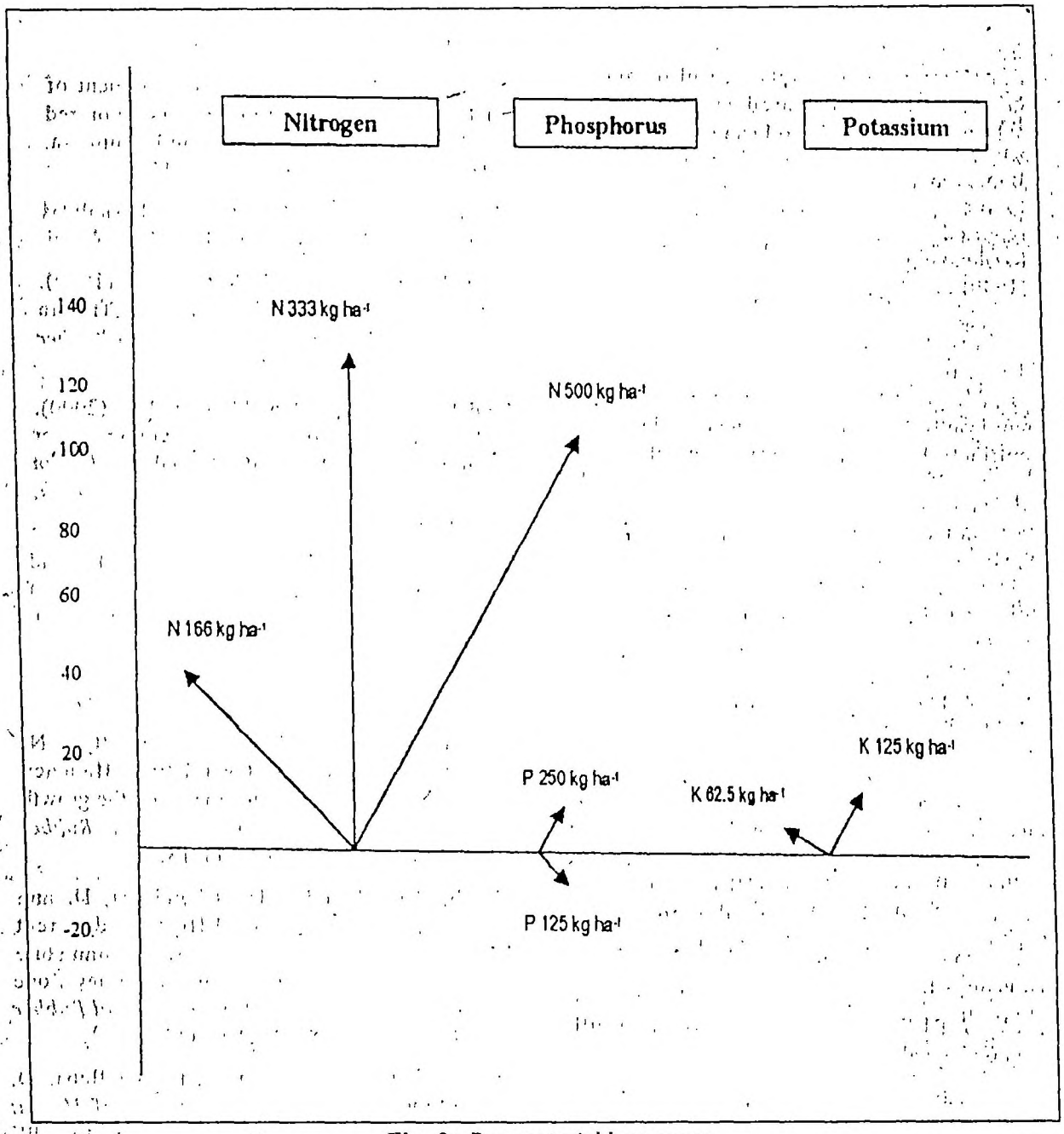

Fig. 2: *Per cent yield response*

available P_2O_5 and K_2O (kg ha^{-1}) are given Table 2. Addition of nitrogenous fertilizers increased the organic carbon content from 11.8 to 15.3 g kg^{-1} in surface soil and 8.6 to 14.3 g kg^{-1} in sub soil respectively and its subsequent decomposition increased the available N, P and K in soil significantly. Application of P fertilizers significantly increased the available P_2O_5 from 14.34 to 21.06 and 4.93 to 7.84 kg ha^{-1} in surface and sub-surface soil, respectively. A significant increase of available K in soil was noticed and its value was increased from 270.82

to 301.06 kg ha^{-1} and 255.84 to 272.83 kg ha^{-1} in surface and sub-surface soil, respectively. The results showed that available P and K contents increased significantly with higher levels of K application. Similarly, soil organic carbon content also increased significantly. Improved nutrient status in soil can be attributed to the application of chemical fertilizers as reported in the case of immature rubber by Krishnakumar and Potty (1989); Singh, *et al.* (1999) and Mandal *et al.* (2000).

CONCLUSION

The results revealed that highest dry matter yield was recorded under the combinations of N_{333} P_{250} $K_{62.5}$ kg ha^{-1}. Application of N, P and K significantly increased their content and uptake of nutrients by the plant. Apparent Nutrient Recovery, Percent Yield Response and soil available nutrient status were increased with increasing levels of N, P and K. The interaction effect among the treatments on N and K uptake by plants was found significant. It was also observed that application of N beyond 333 kg N ha^{-1} was not economical. Further, the efficiency of the applied fertilizers also increased, indicating better utilization of resources.

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