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RESPONSE OF RUBBER TO POTASSIUM FERTILIZATION ON A LATERITE SOIL

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ABSTRACT

Studies on the response of mature rubber (*Hevea brasiliensis* Mud., Arg., clone RRIM 600) to different levels of potassium (K) application in a laterite soil in the low available (morgan extractable) 'K' status showed an increase in the volume of latex and dry rubber yield with K application upto 600 kg/ha^{-1}. Dry rubber content was not influenced by potassium application. Linear, quadratic and cubic response models were fitted for the rate of 'K' supply and the mean annual volume of latex and dry rubber yield. The response was similar during all the three years of study, but treatment differences gradually narrowed in the second and third year. There was a positive correlation between 'K' application and available 'K' status in the soil and 'K' concentration in the leaf.

INTRODUCTION

In plant nutrition potassium (K) plays a major role in photosynthesis, in the synthesis of carbohydrates, protein and fat, translocation of metabolites, promotion of meristematic activity, stomatal regulation, osmoregulation, water balance in the plant system and activation of enzymes (Mengel, 1985). The red and laterite soils where rubber (*Hevea brasiliensis*) is generally grown are inherently deficient in K (Pushpadas and Karthikakutty Amma, 1980).

In Malaysia, for yield stimulation in high yielding clones with better management practices and intensive tapping systems, K was reported to be the most critical nutrient. In India also Punnoose *et. al.* (1978) reported that application of K @ 100 Kg ha^{-1} significantly increased the yield from fourth year of tapping and continued till the seventh year of tapping. According to Sivanadyan *et. al.* (1975) lack of K during early stages of plant growth limits the active leaf area and reduces the photosynthetic activity resulting in slow girth increment and prolonged immaturity period. However, Abdul Kalam *et. al.* (1980) observed that application of K @ 60kg ha^{-1} suppressed the girth increase at four and five and half years after planting.

Pushparajah *et. al.* (1975) have reported that K significantly improved the bark thickness (bark regeneration), phloem thickness, size and number of latex vessels per unit bark. By improving bark quality K increases the flow rate of latex on tapping and also helps to prevent precoagulation of latex associated with excessive application of Mg or due to high soil Mg. The positive influence of K on latex flow and the stability of latex concentrates was reported (Tupy, 1973 and RRIM, 1979). However Pushpadas *et. al.* (1975) correlated higher percentage of tapping panel dryness with higher levels of K application. The present study was conducted to investigate the effect of graded levels of K on the volume of latex, dry rubber yield, on the availability of K in the soil and on leaf K status.

MATERIALS AND METHODS

A field experiment on mature rubber (clone RRIM 600) tapping on the B02 panel on a laterite soil, low in available K status was conducted for three years from 1991 to 1993. The treatments were, seven levels of K_2O, Viz., 0, 15, 30, 45, 60, 75 and 90 kg ha^{-1} supplied in the form of potassium chloride, replicated thrice in randomised block design. The plot size was 24 trees, planted at a spacing of 22 x11 ft. The N and P were supplied through urea and mussoorie rock phosphate @ 30kg ha^{-1} respectively in all the treatments. Ferilizers were applied in two equal splits, one in April-May and other in September-October, continuously during three years of study (1991-93).

Volume of latex and dry rubber content were recorded monthly and the annual average yield was calculated and expressed as per tree per tapping basis. Dry rubber yield was calculated by multiplying the volume of latex with dry rubber content. Every year, soil samples at two depths, viz., 0-30cm and 30-60cm and leaf samples during September-October before application of the second dose of fertilizers were collected and analysed for the available K status in soil using morgan extractant (Morgan, 1941) and concentration of K was estimated from dry ashed samples through an autoanalyser. The data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Fertility Status of the Field

The initial fertility status of the field expressed through soil and leaf testing is given in Table I. The soil was low in available K status (4.68 mg $100g^{-1}$ soil for the surface layer 1.62 mg $100g^{-1}$ soil for the subsurface layer). The soil was acidic in reaction and the organic carbon status was high. The available P status was low. Leaf K content was 1.12 per cent (medium level) before the starting of the experiment. The N, P, Ca and Mg status was high in the foliage as per the sufficiency range ratings (Pushpadas and Ahammed, 1980).

Latex Yield

The effect of potassium on volume of latex is given in Table II. During 1991, the highest volume of latex was recorded with the application of 60kg K_2O ha^{-1} followed by 30kg K_2O ha^{-1}. The yield in 60 kg K_2O ha^{-1} was found to be significantly superior over the 15, 45 and 90 kg levels which were lower than the yield in control. During 1992 and 1993 also though similar trend was noticed, the treatment effects narrowed down and were not statistically significant. Higher levels of K application, at 75 and 90 kg recorded lower yields during the three years. Pushpadas *et. al.* (1975) reported deleterious effect of excessive application of K on latex yield and the possibilities of reduced flow and drying of the tapping panels. But in the present study, there was no correlation

Table I. Initial fertility status

Depth (cm)	Soil				Leaf nutrient concentration				
	pH	O.C. (%) mg	P $100mg^{-1}$	K soil	N	P	K	Ca	mg
0-30	4.9	2.37	0.70	4.68	3.91	0.26	1.12	1.09	0.51
31-60	4.9	1.57	0.18	1.62					

Table II. Effect of potassium on latex production

Treatment K_2O ha^{-1} (kg)	Latex/tree/tapping (ml)		
	1991	1992	1993
0	190	111	121
15	175	105	114
30	196	129	130
45	177	115	115
60	222	135	124
75	191	109	118
90	173	114	109
CD	33.0	NS	NS
Response (R^2)			
L	0.01	0.01	0.14
Q	0.15	0.41	0.35
C	0.48	0.42	0.41

*,** Significant at P = 0.05 and 0.01 levels respectively NS-Non significant, L-Linear, Q-Quadratic and C-Cubic

between the yield and drying up of the panel at higher levels of K application.

Dry Rubber Content

Dry rubber content (DRC) was not influenced by the application of K (Table III). The lowest DRC (33.4 per cent) was recorded with 60 kg K_2O ha^{-1} with the highest volume of latex. Similarly, with reduction in the volume of latex, a corresponding reduction in DRC was observed during all the years.

Dry Rubber Yield

The dry rubber yield for the three years are given in Table IV. The effect of treatments was not statistically significant during the three years of study. The highest dry rubber yield was recorded with 60kg ha^{-1} followed by 30kg ha^{-1} during 1991 and 1992. However, during 1993, highest dry rubber yield was recorded

Table III. Effect of potassium on mean annual dry rubber content (%)

Treatment K_2O ha^{-1} (kg)	Dry rubber content (%)		
	1991	1992	1993
0	36.0	38.7	38.5
15	39.0	40.5	37.8
30	36.6	39.2	37.5
45	38.8	39.6	37.9
60	33.4	38.4	37.6
75	36.5	38.8	38.2
90	38.1	40.0	37.3
CD	NS	NS	NS

NS-Non significant

Table IV. Effect of potassium on dry rubber yield

Treatment K_2O (%) ha^{-1} (kg)	Dry rubber yield/tree/tapping		
	1991	1992	1993
0	65.2	41.2	44.7
15	65.0	44.0	42.0
30	69.3	48.3	47.6
45	64.8	43.7	42.7
60	73.0	50.2	45.7
75	67.3	41.8	44.0
90	63.5	43.4	40.3
CD	NS	NS	NS
Response (R^2)			
L	0.01	0.01	0.12
Q	0.34	0.41	0.35
C	0.49	0.42	0.44

*,** Significant at P = 0.05 and 0.01 levels respectively, NS-Non significant, L-Linear, Q-Quadratic and C-Cubic

with 30 kg ha^{-1} followed by 60 kg ha^{-1}.

Application of K had an effect only on the volume of latex and the effect was statistically significant only during first year. The dry rubber content was not significantly influenced and consequently the numerical differences in dry rubber yield might be due to the changes in volume of latex.

Available Potassium

During first year, no significant change in K status was observed in any of the treatments (Table V). During the second year, availability of K was increased with higher levels of K application. But the treatmental effects were not statistically significant. During 1993, the K status of surface soil was increased at higher levels of K application (Table VI). Available K during 1993 ranged from 3.71 to 6.16 mg $100g^{-1}$ soil.

Further during 1993, appreciable change in available K status of the subsurface soil was observed with 75 kg and 90 kg application. This might be due to the leaching and downward movement of K at higher levels of application. In a low K status soil the surface soil K was brought to medium level (5.0 - 12.0 mg $100g^{-1}$ soil) with the application of potassium at 45 kg or above during the second and third year of continuous applications.

Palaniswamy *et. al.* (1978) reported that the rubber growing soils of South India are low to medium in available K status. Compared to the surface soil, the available K status was very low in the subsurface layer. High organic carbon status and cation exchange capacity in the

Table V. Effect of potassium on available K status in the surface soil

Treatment K_2O ha^{-1} (kg)	K status (μg $100g^{-1}$ soil)		
	1991	1992	1993
0	2.13	3.71	3.71
15	4.13	3.17	4.08
30	3.67	3.16	3.25
45	4.54	5.80	7.13
60	3.83	8.29	5.83
75	2.83	9.79	8.33
90	3.54	8.20	6.16
CD	NS	NS	2.54
Response (R^2)			
L	0.01	0.78	0.62
Q	0.44	0.78	0.45
C	0.85	0.99	0.84

*,** Significant at P = 0.05 and 0.01 levels respectively, NS-Non significant, L-Linear, Q-Quadratic and C-Cubic

Table VI. Effect of potassium on available K status in the subsurface soil

Treatment K_2O ha^{-1} (kg)	K status (μg $100g^{-1}$ soil)		
	1991	1992	1993
0	1.67	1.42	1.96
15	1.63	2.30	1.50
30	3.21	2.34	2.96
45	2.33	2.41	2.71
60	1.71	3.41	3.04
75	2.21	3.69	5.63
90	3.79	3.13	3.88
CD	NS	NS	3.08

NS-Non significant

surface soil contributing towards increased availability of K from the exchangeable pool in the surface soil was reported earlier by Mercykutty Joseph *et. al.* (1990). The levels of K fertilizer application and soil available K status exhibited significant positive correlations during 1992 (r=0.884**) and 1993 (r=0.751*). The available K status in the surface soil registered positive correlation with leaf K concentration during 1992 (r=0.764*) and 1993 (r=0.717*) (Table VIII).

Monitoring leaf K content with K fertilizer application is very important for giving the fertilizer recommendation. Positive significant correlations were observed between the rate of K supply and leaf K concentration during 1991 (r=0.957**), 1992 (r=0.951**) and 1993 (r=0.808**) (Table VIII). The results of the study conform that application of K to soil is correctly reflected on the foliage and the availability of K to the plants can be assessed through leaf testing in rubber.

Table VII. Effect of potassium on leaf potassium concentration (%)

Treatment K_2O ha^{-1} (kg)	Year		
	1991	1992	1993
0	1.07	1.08	0.86
15	1.09	1.13	1.13
30	1.11	1.14	1.12
45	1.16	1.13	1.40
60	1.15	1.16	1.33
75	1.25	1.20	1.26
90	1.25	1.22	1.36
CD	NS	NS	NS
Response (R^2)			
L	0.92*	0.60	0.65
Q	0.93*	0.81*	0.83*
C	0.94**	0.84*	0.84*

*,** Significant at P = 0.05 and 0.01 levels respectively, NS-Non significant, L-Linear, Q-Quadratic and C-Cubic

Leaf K Concentration

Increased K concentration with K application was observed during the three years (Table VII). The gradation was more prominent during 1993, with the control plants registering very low values of K. The values were 0.86 and 1.51 per cent respectively for 0 and 90 kg K_2O ha^{-1} during 1993. The medium range of leaf K fixed for diagnosis is from 1.0-1.50 per cent.

Even though, very low value of K (0.86%) was recorded in the control plot during the third year of continuous withdrawal of K for three years, it was not reflected directly on the yield. But it can be assumed that the low K content of leaves during August, 1993 will be reflected on the yield in coming years.

Response Models

Response models of linear, quadratic

Table VIII. Linear regressions and correlation coefficients

Sl. No.	X	Y	Regression equation	r
01.	Fertilizer K	Soil available K (surface) (1992)	2.250 + 0.081X	0.884**
02	Fertilizer K	Soil available K (surface) (1992)	3.524 + 0.044X	0.751*
03.	Fertilizer K	Soil available K (surface) (pooled over three years)	3.035 + 0.043X	0.590**
04.	Fertilizer K	Soil available K (subsurface) (1992)	1.710 + 0.021X	0.885**
05.	Fertilizer K	Soil available K (subsurface) (1993)	1.586 + 0.034X	0.802*
06.	Fertilizer K	Leaf K (1991)	1.058 + 0.0021X	0.957**
07.	Fertilizer K	Leaf K (1992)	1.089 + 0.0038X	0.951**
08.	Fertilizer K	Leaf K (1993)	0.997 + 0.0047X	0.808*
09.	Fertilizer Z	Leaf K (Pooled over three years)	1.040 + 0.0031X	0.710**
10.	Soil available K	Leaf K (1992)	1.080 + 0.012X	0.764*
11.	Soil available K	Leaf K (1993)	0.817 + 0.071X	0.717*
12.	Soil available K	Leaf K (Pooled over three years)	1.051 + 0.026X	0.432*

* ** Significant at P = 0.05 and 0.01 levels respectively

and cubic form were developed to relate fertilizer K rate with volume of latex, dry rubber yield, available K status and leaf K concentration. In the case of volume of latex (Table II) cubic function was more correctly fitting with higher R^2 value of 0.48 during 1991. During 1992 and 1993, the R^2 values associated with quadratic model were increased but still cubic model gave highest R^2 values. The pattern was same for dry rubber yield also (Table IV). Because of the non-significance of the effect of K application on the dry rubber yield, the calculation of optimum K requirement through these regression techniques was not possible.

In the case of available K status of the surface soil the linear, quadratic and cubic models expressed high R^2 values except in the case of linear model during 1991 (Table V). Similarly the fertilizer K_2O and leaf K concentration models also exhibited significant R^2 values for all the three functions (Table VII).

To conclude, the effect of K application to mature rubber on volume of latex, dry rubber content and dry rubber yield was monitored for three years. The results indicated that at low status of soil available K response to K application was observed upto 60 kg ha^{-1} on increasing the volume of latex. The dry rubber yield was improved through an increase in volume of latex, but the effect was not statistically significant.

Positive significant correlations were recorded between applied K and available K status of the soil and build up of soil K status was recorded at higher levels of K application. Similarly positive significant correlations were recorded between application of K and leaf K concentration. Continuous withdrawal of K resulted in appreciable decrease in leaf K concentration. Regarding the response model to K application on yield of rubber cubic pattern was observed as in many other crops. K requirement could not be worked out since there was no significant effect of K application on dry rubber yield. However, for maintaining the fertility status of the soil and sustainability of land use of maintenance dose ranging from 15-30 kg K_2O ha^{-1} can be recommended in soils having medium available K status. The discriminatory application of fertilizers based on soil and leaf analysis will be more effective and the results of this experiment provides theoritical support for giving fertilizer recommendation specific to individual holdings.

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