Response of Rubber (*Hevea brasiliensis* Muell. Arg.) to Applied Potassium in India

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ABSTRACT

The response of *Hevea brasiliensis* to applied potassium (K) at various growth stages in India as per results obtained in eleven field experiments are discussed. In seedling nursery, benefits from K application was noticed only in soils where the available K status was low. It appears that generally, a low level of K application is sufficient for seedlings. During the immature phase of rubber trees also no response to K application was noticed where the available K status in soil was medium to high. In many cases, K application depressed growth, particularly at higher levels of application. However, during the later half of immature phase when there is enormous release of nitrogen (N) from decaying legume ground cover, application of K was found to be beneficial even at relatively higher doses. In mature rubber, doses around 30 kg K_2O ha^{-1} was found to increase the yield where the available K status in soil was in medium range. The response to higher doses was variable. Residual effect of applied K in influencing yield was also observed at higher levels of application.

2.0 INTRODUCTION

Potassium is the most important cation in plants and is usually absorbed in large quantities by plants. It is important in many plant processes such as activation of enzymes, stomatal regulation, osmoregulation, photosynthesis and respiration (Rama Rao and Sekhon, 1989).

Turgor build up in majority of plant cells require K. It also contributes to disease resistance in plants (Sekhon, 1985). Beringer and Nothdruft (1985) reported that K nutrition increase the sink capacity of plants.

In the case of rubber (*Hevea brasiliensis*), since the harvested produce itself is a hydrocarbon, nutrient removal through latex is small. Hence the nutrient demand for mature rubber could be minimal. This was supported by the results of early experiments and even negative responses to K application was reported (Akhurst and Owen, 1950). With the use of clones having high yield potential and depletion of soil K over years application of K has become a standard practice in most rubber estates. Pushparajah (1977) estimated the total K removed by rubber over a thirty year period (25 years of tapping) as 451 kg ha^{-1} in Malaysian soils. The amount of K immobilized in the tree greatly exceeds the quantity drained through the latex. On a medium K soil, the amount of immobilized K in the tree has been estimated at 1400 kg K ha^{-1} (Lim, 1977). A number of reports from Malaysia and Sri Lanka are available which indicate varying responses to applied K during both immature and mature phases of rubber (Lau Chee Heng, 1979; Yogaratnam and Weerasuriya, 1984; Dissanayake and Mithrasena, 1986 and Rubber Research Institute of Malaysia, 1981, 1983 and 1987).

The Rubber Research Institute of India, since its inception in 1955 conducted a large number of manurial experiments in the major rubber growing tracts of India. This paper envisages to elucidate the results of these experiments with respect to the response of rubber to application of K at different stages of growth.

3.0 MATERIALS AND METHODS

The results of ten experiments conducted in South India and one in Tripura are discussed. Out of these, one experiment was on seedling nursery, five were on immature trees and remaining five were on mature trees. The experimental details are summarised in Table 1.

In the case of seedlings the diameter at the collar region and the height from the collar to the growing apex were taken as growth indices. Girth of

Table 1. *Details od experiments*

Experiment	Description
1. *Seedling nursery* II trials in 6 locations	3^3x2 NPKMg experiment in 2 replications Material - Tjir I seedlings Plot size - 3.6 m^2, 16 recording points Levels of N, P_2O_5 and K_2O-0,247 & 494 kg ha^{-1} Levels of MgO-O & 79 kg ha^{-1}
2. *Immature rubber* (a) Kulasekharam (b) Mundakayam (c) Thodupuzha (d) Palapilly	3^3 NPK in 2 replications Material - (a) PB 5/139 buddings, (b) PB 5/60 buddings (c) Tjir I seedling rees (d) PB 86 buddings Plot size - 6-18 recording points Levels of N-O, 34 & 68 kg ha^{-1} Levels of P_2O_5 & K_2O - 0,45 & 90 kg ha^{-1}

3.	Ranni (Central Experiment station, RRII)	2^4NPKMg with no manure plots Replications - 2 Material - Buddings of RRIM 600, RRIM 605, PR 107 and Tjir I Plot size - 25 recording points Levels of N & K_2O - 30 & 60 kg ha^{-1} Levels of P_2O_5 - 50 & 100 kg ha^{-1} Levels of MgO - 0 & 20 kg ha^{-1}
4.	Keerippara (Tamil Nadu)	Material - Tjir I seedling trees Plot size - 16 recording points 3^2x2 NPK in 4 replications Uniform manuring for intitial 4 years with NPK and then imposition of the treatments Levels of N & K_2O-0, 50 & 100 kg ha^{-1} Levels of P_2O_5 - 0 & 50 kg ha^{-1}
5.	Ranni (Central Experiment Station, RRI)	Material - RRIM 600 buddings Plot size - 25 recording trees 2 separate experiments, one with legume ground cover (Pueraria phaseoloides) and the other with naturally existing ground cover. Uniform manuring with NPKMg for initial 3½ years and then imposition of the following fertiliser treatments - N at 20 & 40 kg ha^{-1} for legume cover N at 40 & 80 kg ha^{-1} for natural cover P_2O_5 at 0 & 20 kg ha^{-1} for both K_2O at 16 & 32 kg ha^{-1} for both MgO at 0 & 6 kg ha^{-1} for both
6.	Tripura (Regional Research Station, RRII)	Material - RRIM 600 buddings 3 levels of NPK K_2O - 5 & 10 kg ha^{-1} during first year -20 & 25 kg ha^{-1} during second year -25 & 30 kg ha^{-1} during third year
Mature rubber		
7.	(a), (b), (c), (d) Yielding phase of Experiment 2	Treatments as detailed in Experiment 2 Yield of initial 5 years under study
8.	Refer Experiment 7d	Half the trees in each plot stimulated with 'Ethrel'
9.	Yielding phase of Experiment 4	Yield for 8 years studied Fertilizer treatments were discontinued during the latter 4 years of study
10.	Yielding phase of Experiment 3	Yield for 3 years and growth for 5 years studied
11.	Yielding phase of Experiment 5	Yield for 5 years studied

the trees was recorded at a height of 125 cm from bud union for budded plants and 50 cm from the ground for seedling plants.

Yield was recorded on one or two tapping days for every month and the mean yield (g $tree^{-1} tapping^{-1}$) was estimated. Soil and leaf analyses were also undertaken periodically for better interpretation of the results. The soil and leaf K concentration values were rated as low, medium and high based on the standards followed by the Rubber Research Institute of India.

4.0 RESULTS AND DISCUSSION

4.1 *Response of Rubber Seedlings to Application of K*

4.1.1 *Experiment 1* (Punnoose *et al.*, 1975)

Response to K application was noticed only in one trial (Table 2) where the available K was low. Potassium application depressed growth in another trial (Table 2) where the soil was medium in available K. It appears that A relatively low level of K is sufficient for seedlings. This is in agreement with the reports of Lau Chee Heng (1979) and Dissanayake and Mithrasena (1986).

4.2 *Response of Immature Trees to Application of K*

4.2.1 *Experiment 2* (Ananth *et al.*, 1966)

No significant effect of K application on growth of trees during the entire immature phase was noticed in any of the locations in this particular experiment. In most cases a depressing trend was observed particularly at the 90 kg K_2O ha^{-1} level. This negative response could be attributed to the high levels of K applied in these trials and the medium to high available K status in the experimental areas (8.31-15.75 mg 100 g^{-1}).

4.2.2. *Experiment 3* (Abdul Kalam *et al.*, 1977)

The girth at four years and five and a half years after planting as well as the girth increment between these years were significantly depressed by K application at 60 kg K_2O ha^{-1} level (Table 3). Application of K also did not increase the leaf K content and the available K in the soil was in the medium range (8.32 mg 100 g^{-1}).

4.2.3. *Experiment 4* (Punnoose *et al.*, 1978)

The girth of trees as well as the girth increment from the fifth year of planting to the commencement of tapping did not give response to application

Table 2. *Effect of potassium on height and diameter of seedlings*

Experiment	Mean height (cm) K_2O kg ha^{-1}			S.E.	C.D. 5%	Mean diameter (mm) K_2O kg ha^{-1}			S.E.	C.D. 5%
	0	247	494			0	247	494		
1.1	179.60	188.80	188.90	2.69	7.60	18.26	18.82	19.39	0.235	0.668
1.2	187.70	185.70	180.30	2.07	5.90	-	-	-	-	-

Table 3. *Effect of potassium on girth and girth increment*

Levels of K_2O (kg ha^{-1})	Mean girth (cm)		
	4 years after planting	5½ years after planting	Girth increment (cm)
30	20.03	38.63	18.53
60	17.46	38.13	17.61
SE	0.567	0.795	0.296
CD (5%)	0.692	2.372	0.883

Table 4. *Effect of potassium on girth increment*

Levels of K_2O (kg ha^{-1})	Mean annual girth increment (CM)
16	9.18
32	9.93
SE: 0.23	CD (5%) 0.70

of K. This period being the latter half of immaturity might have had the beneficial effects of uniform manuring with NPK mixture during the initial four years as well as the effects of nutrient release from the decaying leguminous ground cover exhibiting high K content of soil in the experimental area (15.35 mg 100 g^{-1}). This could be the reason for absence of response to K as well as to N and P observed during this period.

4.2.4. *Experiment 5* (Potty *et al.*, 1978)

In this experiment the mean girth increase during the latter half of immaturity showed response to higher levels of K application only in the legume cover maintained area (Table 4). Higher levels of K may be necessary to keep a proper balance between K and the large amounts of N released during the decay of legume cover during this period. Such response to K application was absent in the natural cover maintained area. The available K status in both the trial areas was in medium range (5.97 mg 100 g^{-1} in legume and 7.28 mg 100 g^{-1} in natural cover).

Table 5. *Effect of NPK on girth*

Treatment*	Mean girth of young trees (cm)		
	First year	Second year	Third year
Existing dose	2.977	10.36	16.51
Higher dose	3.317	10.92	18.09
CD (5%)	0.488	0.891	1.52

*Details given in the text.

4.2.5 *Experiment 6* (Krishnakumar and Potty, 1989)

This experiment was conducted at the Regional Research Station, Tripura using doses of NPK higher than the current recommendation for traditional rubber growing tracts viz., 10:10:10, 40:40:20 and 50:50:25 N, P_2O_5 and K_2O kg ha^{-1} for the first, second and third years, respectively. The increase in doses for this experiment was 100 per cent for the first year, 25 per cent for the second year and 20 per cent for the third year of planting. The levels of K_2O applied were 5 and 10 kg ha^{-1} during the first year, 20 and 25 kg ha^{-1} during the second year and 25 and 30 kg ha^{-1} during the third year. The girth of the young trees showed increasing trend during the initial two years which assumed statistical significance during the third year (Table 5). The available K status of soil was in the medium range (7.08 mg 100 g^{-1}). The results clearly indicate that there is a higher need for NPK in general in Tripura compared to the traditional areas. This may be due to the differences in agroclimatic and soil conditions between North India and South India where all the other experiments described are conducted.

The absence of response to applied K and its depressing effect on growth during immature phase generally noticed in experiments 2 to 5 are in agreement with the reports of Rubber Research Centre, Thailand (1970) and Rubber Research Institute of Malaysia (1983). The maintenance of legume ground cover during the immature phase might have enriched the soil and contributed towards greater availability of all nutrients.

4.3 *Response of Mature Rubber to K Application*

4.3.1 *Experiment 7* (Narayanan Potty *et al.*, 1976)

The yield data during the initial five years of tapping in four different locations are discussed. In two locations (Kulasekharam and Mundakayam) the effect of K application was not significant. A depressing trend was noticed at the higher level of application. At location, Thodupuzha during one year, K application at 90 kg K_2O ha^{-1} significantly depressed yield. Application of K at 45 kg K_2O ha^{-1} as well as no K application were on par (Table 6). During the remaining three years the effect of K was not significant,

Table 6. *Effect of potassium on yield (Thodupuzha)*

Levels of K_2O (kg ha^{-1})	Mean yield (g $tree^{-1}$ $tapping^{-1}$)
0	26.40
45	27.00
90	21.40
SE	1.68
CD (5%)	4.80

Table 7. *Effect of potassium on yield (Palapilly)*

Levels of K_2O (kg ha^{-1})	Mean yield (g $tree^{-1}$ $tapping^{-1}$)
0	26.10
45	24.20
90	23.60
CD (5%) for comparison of K_0 with K_1 or K_2	1.87
CD (5%) for comparison of K_1 with K_2	1.79

but the same trend was observed.

The analysis of variance of mean annual yield for four years taken together showed significant negative response to K application at both the levels at Palapilly (Table 7). The status of available K in all the four locations was in the medium range. However, at Thodupuzha and Palapilly comparatively better K availability could be expected owing to the specific soil features of these locations viz., micaceous nature at Thodupuzha and fine texture and good depth at Palapilly. In these situations further application of K to soils might have created a nutritional imbalance resulting in depression of yield. Depressing effect of K on growth was observed in these locations during the immature phase also (Experiment 2). The negative response to applied K obtained in this experiment is in agreement with the reports of Chan (1972).

4.3.2. *Experiment 8* (George *et al.*, 1977)

The yield data for a period of two years when 'Ethrel' yield stimulation was superimposed in a 3^3 NPK experiment did not show sigificant response to K application. The available soil K status in the experimental area was in the medium range. The possibility for any additional K requirement by stimulated trees in nutrient deficient areas as well as for clones with high production potential cannot be ruled out.

4.3.3 *Experiment 9* (Punnoose *et al.*, 1978)

In an eight year study on mature rubber, K treatments were imposed during the initial four years and the residual effect of applied K was observed

Table 8. *Effect of potassium on yield (g tree^{-1} tapping^{-1})*

Year	Levels of K_2O (kg ha^{-1})				
	0	50	100	SE	CD (5%)
1967-68	14.70	15.80	16.30	0.44	-
1968-69	20.10	20.20	21.40	0.59	-
1969-70	25.80	25.90	27.40	0.75	-
1970-71	38.80	39.70	42.90	0.99	2.83
1971-72	24.60	24.30	27.80	0.73	2.09
1972-73	32.70	34.36	38.50	1.15	3.29
1973-74	32.90	32.70	35.00	0.70	2.00
1974-75	35.70	35.70	38.70	1.03	-

Table 9. *General status of K and leaf K content*

Year	Soil available K (mg 100 g^{-1})	Leaf K (%)
1970	15.39	0.77
1974	5.10	1.12

for another four years. During the first three years there was only numerical increase in yield with increasing levels of K. This response assumed statistical significance during the fourth year and continued up to the seventh year for the higher dose (100 kg K_2O ha^{-1}) (Table 8). During the eighth year also a similar trend was noticed. The available K status was depleted in soil from fourth year onwards but the leaf K content was maintained in the optimum range (Table 9). Significant residual effect of K was observed for yield. This clearly suggests that short term withholding of K fertilizers may not result in a sudden decline in yield provided the soil reserves would be sufficient to maintain the leaf K status at a satisfactory level. Similar results were reported by Rubber Research Institute of Malaysia (1983) and Yogaratnam and Weerasuriya (1984).

4.3.5. *Experiment 10* (Potty *et al.*, 1980)

Increasing the level from 30 to 60 kg K_2O ha^{-1} did not have significant effect on girth of trees at 8½ years and 12 years after planting and also on the girth increment during this period for four clones tried in this experiment. In the case of yield also, similar result was obtained during the above period. The status of available K in soil was in the medium range (7.51 mg 100 g^{-1}).

However, during two years, 1977 and 1979, the N x K interaction on yield was significant (Table 10). During 1977 and 1979 with 30 kg K_2O ha^{-1}, increasing the dose of N from 30 to 60 kg ha^{-1} significantly depressed the yield. During 1977, with 60 kg ha^{-1} of N application, increasing the level of K_2O from 30 to 60 kg ha^{-1} significantly increased the yield indicating that

Table 10. *Effect of NxK interaction on yield (g tree^{-1} tapping^{-1})*

Level of N (kg ha^{-1})	Levels of K_2O (kg ha^{-1})			
	1977		1979	
	30	60	30	60
30	28.00	26.90	40.30	37.60
60	25.20	27.90	36.50	39.60
SE	0.86		1.19	
CD (5%)	2.57		3.54	

Table 11. *Effect of potassium on yield*

Level of K_2O (kg ha^{-1})	Mean yield (g tree^{-1} tapping^{-1})	
	S_1*	S_2**
16	25.20	25.70
32	27.20	26.80
CD (5%)	1.1	

S_1*: Uniform manuring for initial 3½ years of immaturity and then imposing NPKMg treatments.
S_2**: Uniform manuring for initial 7 years of immaturity and then imposing NPKMg treatments.

there should be a proper balance between applied N and K. Similar results were reported by Pushparajah and Chellapah (1969) and Yogaratnam and Weerasuriya (1984)

4.3.5 *Experiment 11* (Mathew *et al.,* 1986)

In the experimental area where legume ground cover was maintained during the immature phase, the yield was significantly increased during the first year of tapping by increasing the dose of K from 16 to 32 kg K_2O ha^{-1} (Table 11). This might be due to the fact that large quantities of N released from death and decay of leguminous cover crop raised during immature phase require higher amounts of K to keep a proper nutrient balance. This is in agreement with the findings of Yogaratnam and Weerasuriya (1984). During subsequent three years there was no difference between the levels of K. The soil available K status was medium (5.25 mg 100 g^{-1}). In a parallel experiment where there was no legume cover during immature phase, no significant difference was obtained between 16 and 32 kg K_2O ha^{-1} levels with respect to yield during the initial four years of tapping.

5.0 SUMMARY AND CONCLUSION

In seedling nursery and in immature rubber during the initial four years, benefits from K application was observed only when soil available K status was poor. Indiscriminate application of K fertilizers at these growth stages depresses growth. Therefore only low doses of K fertilizers need be recommended in these cases.

During the latter period of immature phase and also during the mature phase of trees the response to applied K varied according to early management practices adopted and status of available K in soil. Therefore a policy of need based K fertilizer application based on soil and leaf analyses is advantageous in such cases.

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