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Formulation of multi micronutrient fertilizer for mature rubber plantation

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Abstract

Scientific manuring, by adopting balanced nutrition in perennial plantations is the need of hour for increased productivity and addressing global warming by adopting 4 R nutrient stewardship. Continuous use of NPK in perennial crops can lead to deficiency of micronutrients. Therefore, a study was carried out to understand nutrient status of major rubber growing tracts and to formulate a customized nutrient mixture for rubber. A detailed soil fertility assessment and leaf tissue analysis of mature rubber plantations of age group 11-15 years in five agro ecological units (AEU) in Thiruvananthapuram were conducted during the study. Based on this, a multi micronutrient mixture was formulated for rubber and the composition of the mixture was Zn -3.64 %, B -8.04 %, Fe- 2.01 %, Cu- 2.55 % and Mn-3.25 %. For accessing the effect of the mixture, a field experiment was conducted in existing rubber plantation of RRII 105 replanted in 2005 at Aryanad (AEU 14) in randomized block design with seven treatments and three replications, namely general recommendation of NPK at 30:30:30 kg $ha^{-1}year^{-1}$, soil test based recommendation of NPK at 22:8:21 kg ha^{-1} $year^{-1}$, application of multi micronutrient mixture along with soil test based recommendation of NPK at varying levels from 5 to 15 kg $ha^{-1}year^{-1}$. The treatments had a significant effect on dry rubber content (DRC). For the post monsoon, summer, and annual period, the highest DRC was noticed in 15 kg ha^{-1} of the mixture applied plot which was on par with 7.5 kg ha^{-1} applied plot. Application of micronutrient mixture resulted in enhancement of different micronutrient pools and enriched nutrient storehouse. It was also observed that available micronutrients were within sufficiency level even after application of the mixture. Multi micronutrient mixture application at 7.5 kg ha^{-1} along with soil test based recommendation of NPK can be considered for future studies.

Key Words: Boron,Clone, DRC, *Hevea brasiliensis*, Iron, Nutrient, RRII 105, Soil fertility, Yield

Introduction

Natural rubber is the most versatile industrial raw product having diverse use due to its unique properties of elasticity, toughness, impermeability and non conductivity. Globally, 99 per cent of the natural rubber is obtained from the rubber tree, *Hevea brasiliensis.* As per current statistics, India is the sixth largest producer (839,000 tones) of NR in the world with tapping area of 738,640 ha and having productivity of 1482 kg ha^{-1}, with the monopoly of rubber production in India is by Kerala (Rubber Board, 2023). The rubber growing regions in Kerala are mainly concentrated in four agro ecological units (AEUs): southern and central foothills (AEU 12), northern foothills (AEU 13), southern high hills (AEU 14) and northern high hills (AEU 15) (Kerala State Planning Board, 2013).

Current agro management practices, such as introduction of high yielding clones, mono culture, and repeated cycles of cultivation without adopting proper soil conservation measures, along with its cultivation in undulating topography and sloppy

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terrain have led to a decline in soil health. Extreme low values of bases viz. calcium, magnesium and potassium were recorded in tropical high rainfall rubber growing regions due to leaching loss. Increased usage of nitrogen, phosphorus, and potassium fertilizers alone has resulted in deficiency of secondary and micronutrients. According to Ulaganathan et al. (2012), soil in traditional natural rubber (NR) growing region in India were deficient in available Ca, Mg, S, B, Zn and localized deficiency of Cu and Mn

Rubber is a crop exploited continuously for its latex, after attaining a tappable girth of 50 cm which is usually obtained after 7 to 8 years of planting under Kerala conditions. Latex production is a complicated physiological process, requiring huge amount of energy. Hence role of micronutrients in the crop need special attention.The continuous use of NPK alone indicates that deficiency of other nutrients becomes a limiting factor for growth and yield. Therefore, there is a need to promote balanced fertilization by incorporating secondary and micronutrients to enhance crop productivity. So the study was undertaken to formulate a customized micronutrient mixture which can influence growth and yield in rubber.

Materials & Methods

To study the fertility status of rubber growing regions, a geo referenced survey was conducted in 11-15 years old mature rubber plantations of five agro ecological units in Thiruvananthapuram district. Kerala, India. These units included southern coastal plain (AEU 1), southern laterites (AEU 8), south central laterites (AEU 9), southern and central foot hills (AEU 12) and southern high hills (AEU 14). According to extend of rubber area in different agro ecological units, one hundred and thirty soil samples comprising both surface (0-30 cm depth) and sub surface (30-60 cm depth) were collected and assessed for pH, electrical conductivity, organic carbon, available P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and B.

Table 1. Composition of multi micronutrient mixture for one hectare

Quantity of micronutrient fertilizer (kg)	Nutrient content in the mixture (per cent)
H_3BO_3 - 2	B-8.04
$Na_2B_4O_7.10H_2O$ - 4	
$ZnSO_4.7H_2O$ - 1	Zn-3.64
$CuSO_4.5H_2O$ - 1	Cu-2.55
$MnSO_4.H_2O$ - 1	Mn-3.25
$FeSO_4.7H_2O$ - 1	Fe-2.01

For computation of available micronutrient status in soil, the average of available micronutrients in surface and sub surface samples from surveyed area was taken. Leaf uptake of micronutrients was computed based on average composition of micronutrients in index leaves of rubber collected from different locations and total leaf fall dry weight in one hectare which was accounted to be 2 tones ha^{-1} (Murbach et al., 2003). Based on these data, formulated a customized multi micronutrient mixture by manual mixing of different carriers of micronutrients such as $ZnSO_4$. $7H_2O$, $Na_2B_4O_7$. $10H_2O$ (borax), $CuSO_4$. $5H_2O$, H_3BO_3 (boric acid), $MnSO_4$. H_2O and $FeSO_4$. $7H_2O$ at different proportions. On account of physico chemical characteristics such as solubility in water, pH and EC, the best combination of multi micronutrient mixture for rubber was selected (Table 1) and mixture at 10 kg $ha^{-1}$was fixed as standard dose for application in yielding rubber plantation.

To study the effect of the customized multi micronutrient mixture on yielding rubber plantation, a field experiment was conducted in AEU 14 ($8^0$35'17"N latitude and $77^0$03'57.01"E longitude) using randomized block design with seven treatments and three replications. The plantation was in second cycle of replanting, done in 2005 using poly bag plants of clone RRII 105 at a spacing of 5.8 x 3.4 meter in rectangular system. The field was located at Aryanad, Thiruvananthapuram, Kerala, India has an elevation ranging from 20 to 100m above MSL and slope of 10-15%. Soil belonged to Nedumangad series having taxonomic classification as clayey skeletal isohyperthermic mixed Ustic Haplohumults. The plantation was in fifth year of

tapping when the treatments were applied. The tapping system followed was half spiral cut once in two days represented as S/2d2. Tapping stimulation was not carried out in the plantation.

General recommendation for fertilizer application in yielding rubber, according to, the Rubber Board is 30:30:30 of $N:P_2O_5:K_2O$kg ha^{-1} $year^{-1}$ (Karthikakuttyamma et al., 2000). From initial analysis of soil samples, the soil test based recommendation arrived for the plantation was 22: 8: 25 of $N:P_2O_5:K_2O$ kg ha^{-1} $year^{-1}$ as per NPK rating and recommendations suggested by the Kerala Agricultural University (2016). Fertilizers were applied in rectangular patches in between two trees and gently forked in. Multi micronutrient customized mixture was also applied in rectangular patches in between two trees in different doses as per treatment details along with soil test based recommendation of primary nutrients. Lime was applied at a rate of 600 kg ha^{-1}.

The data obtained were analyzed using Web Agri Stat Package- WASP (ver 2.0). It is an online statistical software package, hosted by ICAR-Central Coastal Agricultural Research Institute, Goa used for analyzing the data. If the effects were significant critical difference at the 5% level of significance was used to compare the means of treatments (Jangam and Thali, 2004).

Results and Discussion

Different parameters like girth increment, dry rubber content, incidence of pest and diseases, available micronutrient status in soil were observed after application of customized multi micronutrient mixture. As indicated in Fig. 1, the highest girth after application of the mixture was noticed in treatment supplied with 7.5 kg ha^{-1} of customized fertilizer while the lowest girth was noticed in treatment receiving general recommendations of NPK alone. Application of micronutrient mixture can enhance crop growth and productivity (Shukla et al., 2021). Similarly Wijaya et al. (2014) also observed the girth increment after application of N P K fertilizer. Nair and Mathew (2019) also observed improvement in plant height, leaf area after application of micronutrient mixture in young rubber plantation.

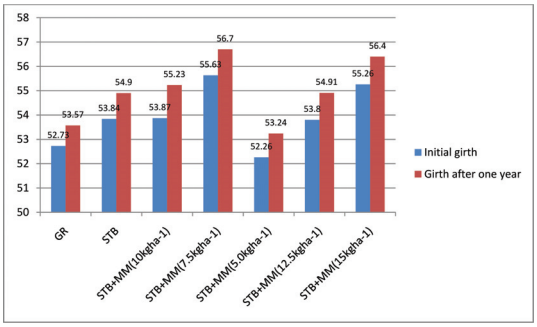

Figure 1. Effect of customized micronutrient mixture on girth of rubber plantation

Dry rubber content usually represented as DRC denotes the weight in gm of rubber present in 100 gm latex. For the post monsoon period, the highest DRC of 39.46 per cent was noticed in treatment receiving 15 kg ha^{-1} of micronutrient mixture (Table

Table 2. Effect of customized micronutrient mixture on Dry Rubber Content (DRC) of mature plantation in different seasons of year, (per cent)

Treatment	Monsoon	Post monsoon	Summer	Annual
GR	32.67	34.58	31.39	32.88
STB	32.17	36.17	32.61	33.65
STB+MM(10kgha^{-1})	32.85	38.06	34.24	35.05
STB+MM(7.5kgha^{-1})	33.25	38.09	33.79	35.05
STB+MM(5.0kgha^{-1})	33.49	37.42	31.68	34.20
STB+MM(12.5kgha^{-1})	33.46	38.99	33.25	35.24
STB+MM(15kgha^{-1})	32.50	39.46	35.10	35.69
SEm (±)	0.44	0.75	0.57	0.38
CD (0.05)	-	2.34	1.78	1.19

GR-General recommendation. STB- Soil test based recommendation. MM- Multimicronutrient fertilizer

Table 3.Effect of customized micronutrient mixtureon tapping panel dryness(TPD)and abnormal leaf fall (ALF) in yielding rubber plantation

Treatment	Per cent Incidence ofTPD*	Percent Disease Incidence of ALF*
GR	10.96 (3.70)	55.50(47.86)
STB	8.36 (3.17)	60.00(50.76)
STB+MM(10kgha^{-1})	9.61(2.93)	46.67(43.00)
STB+MM(7.5kgha^{-1})	10.43(3.40)	47.00(43.06)
STB+MM(5.0kgha^{-1})	8.06(2.97)	40.50(39.20)
STB+MM(12.5kgha^{-1})	10.20(3.40)	38.33(38.18)
STB+MM(15kgha^{-1})	10.17 (3.13)	41.67(40.15)
SEm (±)	(2.44)	(2.88)
CD (0.05)	-	-

GR-General recommendation. STB- Soil test based recommendation. MM- Multimicronutrient fertilizer
*Values in parenthesis denotes transformed values

2). The lowest DRC was noticed in general recommendation of NPK plots. Application of micronutrient mixture may help in enhanced production of metabolites through balanced nutrition (Jacob et al., 1989). C ompost application along with chemical fertilizer and dolomite improved DRC through enhanced latex synthetic process due to the supply of trace elements through compost application (Damrongrak et al., 2015).

Tapping panel dryness (TPD) is a physiological disorder leading to cessation of latex in trees. The lowest incidence of TPD was recorded in 5 kg ha^{-1} of multi micronutrient mixture. Abnormal leaf fall disease (ALF) caused by *Phytophthora* spp. is the most destructive, annually occurring disease of rubber tree in India causing a loss of 38–56 per cent in latex yield, as most of the major cultivated clones are susceptible to this disease (Krishnan et al. 2019). The lowest incidence of ALF (38.18 %) was noted in treatment with multi micronutrient mixture at 12.5 kg ha^{-1} and the highest incidence (50.76 %) was noticed in soil test based recommendation of NPK (Table 3). Application of micronutrient customized fertilizer helped in balanced nutrition thereby imparting tolerance to physiological disorders in rubber. Micronutrients has prominent role in plant defence mechanism, by leading role in membrane stability, controlling lignin and phenolic content in plant cell, promoting carbohydrate, protein metabolism etc. (Dutta et al., 2017).

Application of multi micronutrient mixture resulted in significant increase in available status of majority of micronutrients. Except boron, all the micronutrients were in available range after application of micronutrient mixture, indicating that rubber growing soils are highly depleted of B. Compared to fallow land having available Cu, Zn, Fe and Mn content as 1.49, 0.70, 47.72 and 23.20 mg kg^{-1}respectively, yielding rubber plantation in Tripura had the micronutrient status of 1.40, 0.62, 44.24 and 14.44 mg kg^{-1}respectively. It indicated that adoption of rubber cultivation led to decline in soil micronutrient content which necessitate external application of micronutrients in order to restore soil balance (Mandal et al., 2001).

The recycling of nutrients through leaf litter and acidic nature of soil, favouring availability of micronutrients, has led to least preference for

Table 4. Effect of customized micronutrient mixtureon available micronutrient content of soil from mature rubber plantation (mg kg^{-1})

Treatment	Fe	Mn	Zn	Cu	B
GR	46.43	18.43	0.53	0.95	0.11
STB	62.53	20.24	0.58	1.10	0.09
STB+MM(10kgha^{-1})	94.21	25.59	0.90	1.99	0.24
STB+MM(7.5kgha^{-1})	72.08	27.95	0.70	1.74	0.16
STB+MM(5.0kgha^{-1})	75.88	26.46	0.65	1.79	0.15
STB+MM(12.5kgha^{-1})	100.7	22.38	1.10	2.21	0.25
STB+MM(15kgha^{-1})	108.5	21.62	1.18	3.04	0.36
SEm (±)	5.94	3.24	0.16	0.36	0.05
CD (0.05)	18.52	6.16	0.37	1.11	0.09

GR-General recommendation. STB- Soil test based recommendation. MM- Multimicronutrient fertilizer

Table 5.Effect of customized micronutrient mixture on content of micronutrients in index leaves of mature rubber trees, (mg kg^{-1})

	Fe	Mn	Zn	Cu	B
GR	190.9	118.5	26.69	78.81	69.64
STB	174.7	134.9	28.43	91.98	71.31
STB+MM(10kgha^{-1})	245.4	196.0	42.06	127.8	85.74
STB+MM(7.5kgha^{-1})	189.8	194.4	34.30	121.2	74.01
STB+MM(5.0kgha^{-1})	187.1	138.4	34.74	128.9	73.09
STB+MM(12.5kgha^{-1})	265.9	198.4	44.67	150.6	75.24
STB+MM(15kgha^{-1})	266.8	177.4	43.89	128.6	83.96
SEm (±)	19.17	7.78	2.74	11.49	3.68
CD (0.05)	59.74	24.20	5.98	35.81	-

GR-General recommendation. STB- Soil test based recommendation. MM- Multimicronutrient mixture

micronutrient management in rubber plantation. Rubber plantation is perennial ecosystem and immediate result cannot be expected in terms of yield. However soil application of micronutrients in mature plantation would definitely restore soil micronutrient content and replenish soil health as indicated in Table 4.

After the application of the mixture, the micronutrient contents in index leaves from mature plantation were enhanced, indicating the uptake of nutrients by the tree (Table 5). It was observed that by increased levels of micronutrient fertilizer doses, nutrient content in leaf was also increased. However, in the case of boron, it was noted that even though the soil status showed a deficiency in available boron content in the surveyed areas, the index leaf content from the mature plantation areas remained within the sufficiency range. External application of boron also did not influence leaf nutrient content. This may be due to the lesser influence of boron on the crop, which requires further investigation.

Conclusion

Based on detailed soil fertility assessment and leaf tissue analysis, a customized micronutrient fertilizer was formulated containing micronutrients Zn (3.64 %), B (8.04 %), Fe (2.01 %), Cu (2.55 %) and Mn (3.25 %) for rubber. The fertilizer was applied in yielding rubber plantation at AEU 14 which is in second cycle of replanting. The highest DRC was recorded in 15 kg ha^{-1} applied plot which was on par with 7.5 kg ha^{-1} applied treatment. The lowest incidence of abnormal leaf fall in mature plantation (38.18 %) was noted in treatment with multi micronutrient mixture at 12.5 kg ha^{-1} and the highest incidence (50.76 %) was noticed in soil test based recommendation of NPK. Lowest incidence of tapping panel dryness was recorded in treatment applied with 5 kg ha^{-1} of multi micronutrient mixture and there was no statistical difference observed between different treatments. Comparing to different graded doses of customized fertilizer application, the available micronutrient status was improved one year after application of the mixture indicating that micronutrient pools were enhanced after application of the mixture. With increased levels of customized nutrient mixture, the content of micronutrients in the index leaves were also enhanced. To ascertain the benefits of customized fertilizer, a continuous experiment has to be undertaken in different AEUs using 7.5 kg ha^{-1} of multi micronutrient mixture.

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