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RESEARCH PAPER

Effect of rubber (*Hevea brasiliensis* Muell. Arg.) plantation on nutrient status of soil in hilly zone of Karnataka

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Abstract: Land and soil qualities exert considerable influence on spatial distribution and productivity of rubber in the area. Soil fertility evaluation under different aged rubber growing plantation soils in Hilly zone of Karnataka were studied. Hilly zone was classified into two ecological zones based on annual rainfall distribution *viz*., Mundgod (798 mm) and Sagara (1918 mm). Results indicated soil under rubber plantation were predominantly acidic in nature with pH ranging from 4.29 to 4.81. With increase in age of plantation, the soil fertility reduced considerably with respect to control. The status of soil organic carbon (SOC) and primary soil nutrients were considerably high in Mundgod (low rainfall zone) ranging from SOC (0.60–0.95 %), available nitrogen (308.22–342.88 Kg ha^{-1}), available phosphorous (25.72–29.30 Kg ha^{-1}) and available potassium (180.30–199.37 Kg ha^{-1}), while Sagara (high rainfall zone) experienced low soil nutrient fertility ranging from SOC (0.69-0.82 %), available nitrogen (261.03-284.26 Kg ha^{-1}), available phosphorous (22.22-26.52 Kg ha^{-1}) and available potassium (154.96-167.91 Kg ha^{-1}) which could be due to higher nutrient uptake by trees and leaching loss characterized by site.

Key words: Nitrogen, Rubber, Soil fertility, Soil nutrients

Introduction

Rubber *(Hevea brasiliensis* Muell. Arg.*) i*s well known for its natural rubber production. The tree grows well in the tropics where there is an annual rainfall of 2000-4000 mm and temperature range between 24 to 28 ºC. Hence, its cultivation is concentrated in the humid tropics of the world. The plant thrives best under acidic soil condition where the pH range is 4.0-5.5 *(*Boakye*,* 2015*).* However, its performance and economic viability can be severely restricted where deep, very acidic, rocky parent material is present and drainage is excessive or impeded (Joseph, 2011).

Literature on the status of primary soil nutrients for plantation soils, in addition to varying age of plantation is limited. Therefore, the main objective of the present study was to examine the effect of different site condition and age gradation of rubber plantation on physico-chemical properties of soil.

Material and methods

Fourty eight composite soil samples (0-30 cm depth) under immature (4 year), juvenile (7 year) and early mature (10 year) rubber plantation were collected from two ecological zones *i.e*., Mundgod (14^0 12' 390" N and 75^0 11" 580" E) and Sagara zone (14^0 13' 355" N and 75^0 11' 635" E). Similarly, soil sample was also taken in treeless control site adjacent to plantation during the study period (2016-17). Collected composite soil samples from each replication were air dried, powdered and allowed to pass through 2 mm sieve and analyzed for chemical properties *viz*., soil pH, organic carbon, available nitrogen, available phosphorus and available potassium.

Fertility status of these soils were assessed as per the standard procedure. Soil pH was determined in soil water suspension (1:2.5) using potentiometric method (Jackson 1973), soil organic carbon by using wet oxidation method (Jackson 1973). Available nitrogen was determined using alkaline permanganate method (Subbiah and Asija, 1956), available phosphorous and potassium by Olsen's and ammonium acetate method, respectively (Jackson 1973). Data on soil chemical analysis were subjected to one-way ANOVA using SPSS version 22 at 5 per cent significance level (p = 0.05).

Results and discussion

Results pertaining to soil chemical properties under rubber plantation showed that they were predominantly acidic in reaction with soil pH values ranging from 4.62 to 4.81 in Mundgod zone while comparatively lower pH values were observed in Sagara zone ranging from 4.29 to 4.46 which could be attributed to its higher leaching loss of essential cations or presence of higher sesquoxides (Table 1). Reduction in pH was observed in all age gradation when compared to their respective control sites, which can be attributed to higher organic matter content and high microbial activities resulting in production of high amount of organic acids which in turn lowers the pH of soil with advancement in age of plantation. The organic carbon content of soil in both ecological zone increased with increase in age of plantation over their respective control sites, which could be due to the variation in annual leaf litter addition to soil that might have helped for building up organic matter. However, between two ecological zones, Sagara recorded comparatively lower soil organic carbon ranging from 0.63 to 0.82 % than Mundgod ranging from 0.60 to 0.95 %, which may be due to leaching losses and higher uptake by the trees for its better growth (Table 2).

Table 1. Mean soil pH of rubber plantation

Main plot (M)/ Sub plot (S)	Mean soil pH	
	M_1 - Mundgod	M_2 - Sagara
S_1 - 4 YAP	4.81±0.05[b]	4.46±0.04[b]
S_2 - 7 YAP	4.76±0.05[bc]	4.35±0.05[c]
S_3 - 10 YAP	4.62±0.03[c]	4.29±0.04[c]
Control (without tree)	6.69±0.20[a]	6.45±0.05[a]
F value	316.63*	1746.56*
C.D. (@ 5 %)	0.17	0.08

* Significant at 5 % level. YAP: Year of Planting
Means having same small letters as superscript indicates they are on par (homogenous) column wise

Table 2. Mean soil organic carbon under rubber plantation

Main plot (M)/ Sub plot (S)	Mean organic carbon (%)	
	M_1 - Mundgod	M_2 - Sagara
S_1 - 4 YAP	0.76±0.03[c]	0.69±0.03[c]
S_2 - 7 YAP	0.87±0.03[b]	0.77±0.01[b]
S_3 - 10 YAP	0.95±0.03[a]	0.82±0.04[a]
Control (without tree)	0.60±0.03[d]	0.63±0.02[d]
F value	79.53*	16.03*
C.D. (@ 5 %)	0.05	0.04

** Significant at 5 % level. YAP: Year of Planting
Means having same small letters as superscript indicates they are on par (homogenous) column wise

Table 3. Mean available nitrogen under rubber plantation

Main plot (M)/ Sub plot (S)	Mean available nitrogen (kg ha^{-1})	
	M_1 - Mundgod	M_2 - Sagara
S_1 - 4 YAP	308.22±4.59[c]	261.03±6.12[c]
S_2 - 7 YAP	327.40±6.0[b]	279.02±4.10[b]
S_3 - 10 YAP	342.88±4.35[a]	284.26±3.75[a]
Control (without tree)	152.07±1.87[d]	169.18±4.72[d]
F value	1561.62*	508.71*
C.D. (@ 5 %)	6.88	7.34

* Significant at 5 % level. YAP: Year of Planting
Means having same small letters as superscript indicates they are on par (homogenous) column wise

Table 4. Mean available phosphorous under rubber plantation

Main plot (M)/ Sub plot (S)	Mean available phosphorous (kg ha^{-1})	
	M_1 - Mundgod	M_2 - Sagara
S_1 - 4 YAP	25.72±0.17[c]	22.22±0.29[c]
S_2 - 7 YAP	27.57±0.29[b]	24.45±0.31[b]
S_3 - 10 YAP	29.30±0.39[a]	26.52±0.29[a]
Control (without tree)	17.12±0.20[d]	15.42±0.27[d]
F value	1487.83*	1058.99*
C.D. (@ 5 %)	0.43	0.46

* Significant at 5 % level. YAP: Year of Planting
Means having same small letters as superscript indicates they are on par (homogenous) column wise

Table 5. Mean available potassium under rubber plantation

Main plot (M)/ Sub plot (S)	Mean available potassium (kg ha^{-1})	
	M_1 - Mundgod	M_2 - Sagara
S_1 - 4 YAP	180.30±3.88[c]	154.96±1.93[c]
S_2 - 7 YAP	186.41±2.63[b]	160.99±1.71[b]
S_3 - 10 YAP	199.57±2.93[a]	167.91±1.69[a]
Control (without tree)	116.04±2.45[d]	107.98±1.01[d]
F value	605.20*	706.71*
C.D. (@ 5 %)	4.66	3.15

* Significant at 5 % level. YAP: Year of Planting
Means having same small letters as superscript indicates they are on par (homogenous) column wise

A wide variation was observed in available nitrogen, phosphorous and potassium content under rubber plantation as compared to their corresponding control sites in both ecological zone. Rubber plantation showed an increasing trend with increasing age which may be due to higher addition of organic matter in the form of litter and subsequent decomposition resulting in release of nutrients to soil. However, compared to Mundgod (308.22 to 342.88 kg ha^{-1}), Sagara region recorded lower available nitrogen (261.03 to 284.26 kg ha^{-1}) in all the age gradation which may be due to leaching loss characterized by that site and higher uptake by trees for better growth (Table 3). Available phosphorous content was observed to be low in both the ecological zones which could be attributed to consumption of P_2O_5 by plants due to its essentiality in energy transfer process (Singh *et al.*, 2012). But in comparison with respective control sites, rubber plantation in both ecological zone exhibited higher available phosphorous content and increased with age of rubber plantation which could be due to addition of organic matter in form of litter with increasing age and subsequent decomposition resulting in release of nutrients to soil. However, in Sagara region, available phosphorous (22.22 to 26.52 kg ha^{-1}) was recorded lower than Mundgod region (25.72 to 29.30 kg ha^{-1}) which may be due to leaching loss characterized by that site and higher uptake by trees for better growth (Table 4).

As age advanced, soils under plantation showed an increasing trend of available potassium which may be attributed to nature and distribution of potassium bearing minerals present in soil, addition of organic matter in form of litter with increasing age and subsequent decomposition resulting in release of nutrients to soil (Dasar *et al.*, 2006). However, in Sagara region, available potassium (154.96 to 167.91 kg ha^{-1}) recorded was lower than Mundgod (180.30 to 199.57 kg ha^{-1}) which may be due to leaching loss characterized by the site and higher uptake by trees for better growth (Table 5).

These results were in line with findings of Dasar *et al.* (2006), Singh *et al.* (2012) and Parshuram (2015) in different plantations established in Hilly zone.

Conclusion

The study revealed that, rubber plantation had no deleterious effect on soil chemical properties and soil fertility status improved with advancement in age of plantation. Low level of soil pH and soil organic carbon across the rubber plantation was observed indicating a low level of native soil fertility. The level of available nitrogen and potassium were moderate but phosphorous was found to be too low which should be supplemented in required dosage for better growth.

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