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INFLUENCE OF INTERCROPPING ON GROWTH OF RUBBER (*HEVEA BRASILIENSIS*) AND SOIL PHYSICO-CHEMICAL PROPERTIES

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The influence of intercropping on growth of rubber and soil physico-chemical properties was studied in a field experiment involving three intercropping systems *viz.* rubber/tapioca, rubber/banana and rubber/pineapple in comparison with the standard rubber-cover crop system. Pineapple and cover crop were retained for 3-5 years and three crops of tapioca and banana were raised during this period. The girth of rubber was recorded at periodic intervals at a height of 125 cm from bud union. Soil samples were collected before and 6.5 years after planting from each system and analysed for physical and chemical properties. Bulk density and porosity of soils were not affected by planting different intercrops while an improvement in cation exchange capacity (CEC) and organic carbon status was observed in banana and cover crop established areas. An increase in available phosphorus was noticed in all the systems and the availability of potassium increased significantly in banana area compared to other systems. The tappability of rubber in 6.5 years was 43.75% in banana-intercropped areas. Growth of rubber was superior together with banana compared to other systems while in tapioca, pineapple and cover crop established areas, tappability was 37.8, 17.02 and 37.8 % respectively. The study showed that among the three intercrops and cover crop, banana intercropping is good for improving growth of rubber followed by cover crop and tapioca.

Keywords: Cropping systems, *Hevea brasiliensis*, Intercropping, Physico-chemical properties, Tappability

INTRODUCTION

In India 99% of the rubber plantation units are with smallholders and they cover more than about 90% of the total area and the mean holding size is around half a hectare per grower (Rubber Board, 2011). Since the immaturity period of rubber (*Hevea brasiliensis*) usually exceeds seven years, smallholders are forced to take up intercropping in order to get income during this period. Adoption of cropping system approach is indispensable to increase the productivity per unit area and the success of intercropping in relation to sole cropping depends on how existing agronomic practices can be manipulated to improve the land use efficiency of various intercropping systems (Sen *et al.*,1976; Ofori and Stern, 1986). The ultimate aim of intercropping is not only to obtain additional income but also to improve the fertility status in the long run. Nair (1999) reported that high output from any cropping system will deplete the soil of its nutrient store and make the system

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ecologically unsustainable if the intercrops are not sufficiently manured.

Intercropping is widely practised in most of the rubber growing countries like Sri Lanka, Malaysia, Thailand, *etc*. and the research on crops suitable for intercropping is in progress (Pathiratna and Perera, 2002). In India, many intercrops are grown in rubber plantations and among them, banana and pineapple are more popular. The success of intercropping banana and pineapple in rubber plantation is well documented (Jessy *et al.*, 1998). Even though much work had been done on various aspects of intercropping such as land-use efficiency and suitability of different intercrops, only limited data are available on the changes in physical and chemical properties of rubber growing soils due to cultivation of different intercrops. Therefore, a field experiment was undertaken to monitor the changes in growth of rubber and soil physical and chemical properties due to intercropping in rubber plantations.

MATERIALS AND METHODS

A field experiment was conducted at Travancore Rubber and Tea Estate, Mundakayam for seven years from 2003 to 2009. The average annual rainfall at this place is 2735 mm. Mean temperature ranged from 23.4 ^{0}C (minimum) to 32.4 ^{0}C (maximum). The soil of the experimental site was sandy clay loam in texture. Polybag plants of clone RRII 105 were planted during 2003 at a spacing of 6.7 m x 3.4 m. The four treatments were rubber intercropped with tapioca, pineapple and banana (Nendran verity) and rubber with the cover crop, *Pueraria phaseoloides.*

P. phaseoloides, tapioca, banana and pineapple were planted in between rows of rubber in one block each after planting rubber at a distance of 1.2 m from plant basin. *P. phaseoloides* and pineapple were retained in the field for 3.5 years and three crop harvesting of tapioca and banana were made during this period. The planting techniques, general cultural operations and fertilizer application for both rubber and cover crop were followed as per the recommendations of Rubber Board. The package of practices recommended by Kerala Agricultural University (2003) was followed for other crops. Farm yard manure @ 10 kg/plant and 5 t/ha, respectively were applied to banana and pineapple and bone-meal @ 300 kg/ha was applied to tapioca as basal dose. The residue from the different systems was incorporated into the soil. The recycled biomass included the pruned suckers, leaves, leaf litter and pseudo-stem of the intercrops and cover crop.

Each block consisting of 450 rubber plants was divided into 15 units for soil sample collection. Soil samples were collected at 0-30 cm depth from different blocks before the establishment of intercrops and cover crop, and analysed the physical and chemical properties of the soil. To compare the changes in physical properties, soil samples were collected from the same systems after 6.5 years. Particle density, bulk density, porosity and mechanical properties were determined by following standard procedures (Black, 1965). Soil samples were also collected from each block every year and leaf sampling was done during sixth year of planting for chemical analysis. Soil samples were analysed for organic carbon, pH, available phosphorus (P), potassium (K),calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) and leaf samples were analysed for P, K, Ca, Mg, Fe, Mn, Zn and Cu by standard procedure (Jackson, 1973). Comparison of microbial population in different systems was also made 3.5 years after planting by serial dilution method. The girth of all rubber plants in each block was recorded at six-month interval at a height of 125 cm from bud union.

RESULTS AND DISCUSSION

Girth of rubber was significantly higher in tapioca, banana and cover crop areas than in the pineapple area throughout the experimental period (Table 1). Initially, girth of rubber in the banana intercropped area was significantly lower than in the cover crop and tapioca areas. Even though higher girth was noted in cover crop established area till 5.5 years, maximum average girth of 45.68 cm was recorded in banana intercropped area after 6.5 years followed by cover crop established area and was significantly superior to the other two systems. Visual observations made periodically on the growth pattern of the rubber and intercrops showed that banana over shadowed the rubber plants during the initial years, which may be the reason for poor girth during the early period. Mathew *et al.* (1978) and Chandrasekhara (1984) have reported better growth of rubber when intercropped with banana. There are reports showing favourable effect of intercropping on the growth of rubber due to nutrient build up in the soil (Mohd. Noor *et al.*, 1989; Jessy *et al.*, 1996).

Higher percentage of trees (43.75) in the banana intercropped area attained tappable girth by 6.5 years after planting, while only 17% could achieve tappability in the pineapple intercropped area within this period. Tappability per cent in different systems followed the order banana > cover crop >tapioca > pineapple.

Table 1. **Effect of intercrop on girth of rubber and tappability**

Intercrop/ Cover crop	Girth of rubber (cm) Year after planting			Tappability (%)
	3.5	5.5	6.5	6.5
Cover crop	26.35	38.25	44.00	37.83
Tapioca	25.66	36.84	42.29	37.82
Pineapple	18.82	33.73	39.29	17.02
Banana	21.28	37.03	45.68	43.75
CD (P = 0.05)	1.25	1.90	1.91	

Table 2. **Leaf nutrient status of rubber 6.5 years after planting**

Intercrop/ Cover crop	Content of leaf nutrients (%)								
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
P.phaseoloides	3.55	0.23	1.10	1.47	0.27	333.40	441.67	66.47	240.13
Tapioca	3.65	0.22	0.88	1.22	0.37	344.00	265.87	32.27	70.33
Pineapple	3.24	0.27	0.84	1.26	0.23	333.10	400.73	51.40	97.87
Banana	3.21	0.43	1.17	1.26	0.24	296.53	336.67	59.20	90.00
CD (P = 0.05)	NS	0.09	0.11	NS	NS	NS	NS	11.37	NS

Leaf P, K and Zn status of rubber was significantly influenced by intercropping (Table 2). P content was found to be significantly higher in banana intercropped area than other systems. K content of rubber leaves was on par in banana and cover crop areas and significantly higher than that of the other two intercropped areas. Leaf Zn status was the highest in cover crop established area and it was comparable to banana and significantly superior to tapioca and pineapple intercropped areas. Other leaf nutrients were not affected by planting different intercrops/cover crops.

Data on change in physical properties of rubber growing soil by planting intercrops and *Pueraria* in the inter-row areas are furnished in Table 3.

Table 3. **Change in physical properties of soil**

Bulk density (g/cm3)		
Intercrop/cover crop	Initial	After 6.5 years
P. phaseoloides	1.28	1.26
Tapioca	1.24	1.22
Pineapple	1.29	1.20
Banana	1.26	1.26
Porosity (%)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	41.78	42.54
Tapioca	43.28	44.51
Pineapple	41.36	45.45
Banana	42.53	42.55
CEC (cmol(+)/kg)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	6.53	8.61*
Tapioca	6.30	6.50
Pineapple	5.04	5.55
Banana	4.63	6.09*

*Significant at P≤ 0.05

The bulk density and porosity of soils were not significantly influenced by the different intercrops while an improvement in cation exchange capacity (CEC) was noted in banana and cover crop established areas after 6.5 years (Table 3). The improvement in CEC in banana and cover crop planted areas is attributed to increase in organic matter as compared to other intercropping systems and the results are in concurrence with previous findings (Gao and Chang, 1996). Change in soil nutrient status due to cultivation of intercrops and cover crop is given in Table 4.

Organic carbon content was significantly improved in cover crop (1.79%) and banana (1.86%) areas over initial status while it was not significantly influenced in tapioca (1.22%) and pineapple (1.32%) areas. *In situ* addition and decomposition of organic matter through the decayed cover crop and crop residues from banana would have resulted in organic carbon enrichment in those systems while such addition was comparatively less in tapioca and pineapple intercropping systems. Philip *et al.* (2005) reported that organic matter addition of *P. phaseoloides* in rubber plantations in a 3-year period is more than 5.5 t/ha.

An increase in available P was noticed in all the systems and the difference was significant in tapioca and pineapple intercropped areas at 0-30 cm depth. Bonemeal applied as basal dose to tapioca and its residual effect might have resulted in higher availability of P in the tapioca-intercropped area. Residual effect of P fertilizer was reported by Kwakye *et al.* (1995). Jessy *et al.* (1996) reported an increasing trend in available P status of

Table 4. **Change in nutrient and pH status of soil due to intercrops and cover crop**

Intercrop	Initial	After 6.5 years
OC (%)		
P. phaseoloides	1.39	1.79 **
Tapioca	1.42	1.22
Pineapple	1.55	1.32
Banana	1.08	1.86 **
CD (P = 0.05)	NS	NS
Av. P (mg/100g soil)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	0.58	1.14
Tapioca	0.51	1.42 **
Pineapple	0.25	1.03 **
Banana	0.51	0.91
CD (P = 0.05)	NS	NS
Av. K (mg/100g soil)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	10.32	10.01
Tapioca	15.38	9.62 **
Pineapple	16.44	6.88 **
Banana	11.23	22.63 **
CD (P = 0.05)	NS	9.10
Av. Ca (mg/100g soil)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	14.4	12.41
Tapioca	12.68	12.23
Pineapple	10.57	6.88
Banana	10.37	9.78
CD (P = 0.05)	NS	NS
Av. Mg (mg/100g soil)		
Intercrop	Initial	After 6.5 years
P. phaseoloides	2.22	2.66
Tapioca	2.44	2.29
Pineapple	2.75	1.97
Banana	2.42	2.33
CD (P = 0.05)	NS	NS
pH		
Intercrop	Initial	After 6.5 years
P. phaseoloides	4.95	4.94
Tapioca	4.94	4.93
Pineapple	4.94	4.82 *
Banana	4.81	5.01 **
CD (P = 0.05)	NS	NS

*Significant at P≤ 0.05; **Significant at P≤ 0.01

rubber growing soil when intercropped with banana and pineapple.

A significant increase in available potassium (K) was noted in banana area while a decrease was noted in other cropping systems. The decrease was significant in tapioca and pineapple intercropped systems. There was no significant difference in available potassium status in cover crop-established area. Increase in available K in banana area might be due to the addition of higher quantity of K fertilizer to banana and recycling of the crop residues (Jessy *et al.*, 1996). The decrease in available potassium in tapioca and pineapple areas might be due to luxury consumption of this nutrient by pineapple and tapioca and leaching loss due to soil disturbances. Saikh *et al.* (1998) reported that intensive cultivation and use of acid forming inorganic fertilizers affect the distribution of K in the soil system and enhance its depletion. In cover crop, established area available K content was maintained which confirms the beneficial effect of establishing leguminous covers during the initial years. No significant difference was noted in Ca and Mg status in different systems after 6.5 years.

A significant increase in soil pH was observed in banana area (5.01) compared to the initial value of 4.81, while a decrease

Table 5. **Micronutrient status of soil 6.5 years after planting**

Intercrop/ Cover crop	Micronutrient status (ppm) Fe	Mn	Zn	Cu
P. phaseoloides	49.26	6.59	0.55	5.83
Tapioca	42.98	8.32	0.46	5.92
Pineapple	59.05 **	5.82	0.50	20.02 **
Banana	61.70 **	10.33	0.68	19.99 **
CD (P = 0.05)	16.15	NS	NS	7.67

Table 6. **Microbial population 3.5 years after planting**

Intercrop/ Cover crop	Microbial population (cfu/g soil)			
	Bacteria	Fungus	Actinomycetes	Phosphobacteria
P. phaseoloides	62	79	61	91
Tapioca	91	16	93	31
Pineapple	7	8	8	12
Banana	16	206	200	43

from 4.94 to 4.82 was noted in pineapple area after 6.5 years. Lowering of pH in pineapple area might be due to slow decomposition of organic residues and release of organic acids in pineapple ridges. The soil pH in tapioca intercropped and cover crop-established area was not affected after 6.5 years.

No significant difference was noted among systems in soil organic carbon, available phosphorus, calcium, magnesium and pH. Available potassium was found to be significantly higher in banana-intercropped area after 6.5 years, which might be due to the addition of higher quantity of K fertilizer to banana and recycling of the crop residues.

Significant variation was observed among the different intercropping systems in iron (Fe) and copper (Cu) status (Table 5). Pineapple and banana-planted areas retained significantly higher Fe and Cu content. The lower status of Fe and Cu in tapioca area is probably due to comparatively higher crop removal.

Population of fungi and actinomycetes was the highest in the banana area while phosphobacterial population was the highest under cover crop area followed by banana area (Table 6). In general, a higher microbial population was noticed in banana intercropping system. Difference in count might be attributed to the quantity and quality of organic matter residues recycled to the soil from different systems.

Results of the study clearly showed the superiority of "Nendran banana" as an intercrop in young rubber plantations. Decline of available 'K' in certain intercropping system and build up of 'P' indicate the need for adopting discriminating fertilizer recommendation after intercropping period.

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