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COMPARATIVE EFFICIENCY OF TWO COVER CROPS ON SOIL ENRICHMENT, ACCUMULATION OF NUTRIENTS, MICROBIAL POPULATION AND GROWTH OF *HEVEA BRASILIENSIS* IN MEGHALAYA

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A field experiment conducted in a rubber grower's field near Jorabat, Ribhoi district of Meghalaya, indicated that growing leguminous cover crops, *P.ueraria phaseoloides* and *Mucuna bracteata,* in the immature phase of rubber improved the fertility status of soil, microbial population, soil moisture content, nutrient content in litter and growth of *Hevea brasiliensis.* Establishment of *M. bracteata* by sowing the treated seeds in patches (1 m^2) registered higher organic carbon status, microbial population, soil moisture content and growth of young *H. brasiliensis* than other methods of its establishment or *P.phaseoloides* established by different methods.

Key Words: Cover crop, *Hevea brasiliensis,* Litter, Microbial population, *Mucuna bracteata,* Nutrients, *Pueraria phaseoloides.*

INTRODUCTION

The establishment and maintenance of leguminous cover crops in the immature phase is one of the important agronomic practices followed in rubber (*Hevea brasiliensis*) plantations. The beneficial effects of cover crops *viz.*, improvement of soil physico- chemical properties, fixation of atmospheric nitrogen and addition of large quantity of litter have been well documented (Watson *et al.,*1964). They also help in formation of large soil aggregates and improve infiltration (Krishnakumar and Potty, 1989). Leguminous cover crops contribute much to the nitrogen requirement of rubber plants (Shorrocks, 1965) through root nodule formation by symbiotic nitrogen fixing bacteria. Leguminous ground cover enhances the growth of *H. brasiliensis* during immature phase and helps in attaining higher yield (Watson, 1961; Watson, *et al.*, 1964; Philip *et al.*, 2001; 2005 a).

Pueraria phaseoloides and *Mucuna bracteata* are the two widely cultivated leguminous cover crops in the rubber plantations in India. These leguminous covers vary in their ability to improve the fertility of the soil, depending on the chemical composition and amount of dry matter produced (Kothandaraman *et al.,* 1989).

The comparative efficiency of *M. bracteata* and *P. phaseoloides* on dry matter

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production, nutrient accumulation, soil moisture status, and build up of microbial population have been studied in the traditional rubber growing regions of India (Kothandaraman *et al.,* 1989; Philip *et al.,* 2005 b). Information on the establishment and the beneficial effects of these cover crops in Meghalaya, a non-traditional rubber growing state in India, is lacking. This study has been therefore taken up to compare the efficiency of the leguminous cover crops on improving the soil physico-chemical properties and their influence on growth of *H. brasiliensis* during the immature phase.

MATERIALS AND METHODS

The field experiment was conducted in a small holding near Jorabat, Ribhoi Meghalaya, near Guwahati, at an elevation of 110 m above MSL and receiving about 1800 mm rainfall annually. Pre-treatment soil samples (Typic disdtrudepts) were collected and analyzed for pH, fertility status and microbial population (Table 1). The soil is strongly acidic sandy clay loam .The organic carbon and available K contents were in medium range, available P was low and available Mg was high. The population of fungi, bacteria and actinomycetes in the surface and sub-surface soils were also quantified.

Nine-month-old polybag plants of the clone RRIM 600 were planted in the field after receiving the pre-monsoon rains in June, 1999. Treated seeds of *P. phaseoloides* and *M. bracteata* were also sown between the rows of rubber in three different planting systems *viz.,* planting in single strip, double strips and patches ($1 m^2$). A control treatment without any cover crop, allowing the growth of natural cover, was also included.

The experiment was laid out in randomized block design with seven treatments and three replications. The gross plot size was eighteen plants and net four. Rubber plants were manured twice in a year, during April/May (pre-monsoon) and September (post-monsoon). Routine cultural operations were carried out as per the standard recommendations. Girth was recorded at a height of 15 cm during the first year and at a height of 150 cm from the bud union thereafter for the entire immature phase at periodical intervals. Soil moisture content of each plot during stress period (October-March) was estimated. The fertility changes in the system were also quantified every year. At the end of the fourth year, surface and sub-surface soil samples and litter samples of cover crops and rubber were collected from each plot using quadrate technique and analyzed for the total nutrient accumulation in soil. Organic carbon, available P, K and pH of soil samples were analyzed following the standard analytical procedures (Karthikakuttyamma, 1989). The dry matter production of litter samples were also estimated. The plant samples were analyzed

Table 1. **Pretreatment nutrient status and microbial population of the experimental site**

Soil depth (cm)	Soil pH	Organic carbon (g/kg)	Available nutrients (kg/ha)			Population of microorganisms (Cfu/g of soil)		
			P	K	Mg	Fungi ($\times 10^3$)	Bacteria ($\times 10^5$)	Actinomycetes ($\times 10^5$)
0-30	4.50	10.5	4.02	183.68	369.6	21.3	5.64	2.42
30-60	5.02	8.9	1.79	162.40	280.0	13.9	1.93	0.98

for N, P, K, Ca and Mg as per standard procedures (Piper, 1950).

Soil samples were also collected using a sterilized shovel from two depths (0-30 cm and 30-60 cm) under *P. phaseoloides* and *M. bracteata*. The populations of fungi, bacteria and actinomycetes were estimated by dilution plate method using appropriate media.

RESULTS AND DISCUSSION

Dry matter production

Dry weight of cover crop litter was significantly influenced by the type of cover crop and the planting system (Table 2). Higher litter biomass was recorded in the cover crops planted in patches *M. bracteata* (4253 kg/ha) followed by *P. phaseoloides* (3903 kg/ha) and it was lower for those planted in single strips of *M. bracteata* (3366 kg/ha) and *P. phaseoloides* (3265 kg/ha).

Table 2. **Litter addition by cover crops**

Treatment	Dry weight of litter (kg /ha)
P. phaseoloides in single strips	3265
P. phaseoloides in double strips	3512
P. phaseoloides in patches	3903
M. bracteata in single strips	3366
M. bracteata in double strips	3626
M. bracteata in patches	4253
Natural cover	——
SE	11.89
CD ($P \leq 0.05$)	35.87

Similar results were also reported by Philip *et al.* (2005 a). Higher litter for *M. bracteata* was due to faster and denser growth and higher efficiency in dry matter production compared to *P. phaseoloides*. Kothandaraman *et al.* (1989) have also recorded comparatively higher biomass production for *M. bracteata* than *P. phaseoloides*.

Soil nutrient status

The soil nutrient status of the top and sub-soils were significantly influenced by the presence of cover crops (Tables 3 and 4). The organic carbon content was significantly higher in cover cropped fields compared to those under natural cover. In the surface soil *M. bracteata* planted in patches recorded the highest organic carbon content (12.8 and 13.9 g/kg in the second the fourth years after planting respectively) followed by *P. phaseoloides* planted in patches (12.6 and 13.2 g/kg). The minimum was recorded under natural cover (10.8 and 11.0 g/kg) at the age of two and four years after planting respectively. The percent increase over control was 18.52 and 26.36 for *M. bracteata* established in patches and 16.67 and 20 for *P. phaseoloides* planted in patches in the second and fourth year respectively in the surface soil. The higher dry matter production of *M. bracteata* compared to *P. phaseoloides* might have lead to higher organic carbon status of the *M. bracteata* fields. A similar trend was also observed in the sub-surface soil at the age of two and four years of the cover crops in the rubber plantations. Irrespective of the cover crops, planting in patches resulted in better establishment and improved organic carbon content in the soil.

A similar trend was found in the case of available P in the surface and sub-surface soils. The top soil showed the highest available P (6.94 and 9.18 kg/ha in the second the fourth years after planting respectively) where *M. bracteata* was planted in patches followed by *P. phaseoloides* planted in patches (6.27 and 7.84 kg/ha). The content of available P was minimum in natural cover (4.03 and 4.48 kg/ha) at the age of two and four years after planting respectively.

Table 3. **Influence of cover crops on fertility status of surface soil (0-30 cm)**

Treatment	Organic carbon (g/kg)		Available P_2O_5 (kg/ha)		Available K_2O (kg/ha)		Soil pH	
	2 YAP*	4 YAP	2 YAP	4 YAP	2 YAP	4 YAP	2 YAP	4 YAP
P. phaseoloides in single strips	11.1	12.1	4.70	4.93	183.10	193.80	5.01	4.96
P. phaseoloides in double strips	11.8	12.7	4.48	5.60	183.23	194.70	5.03	4.99
P. phaseoloides in patches	12.6	13.2	6.27	7.84	193.76	200.70	5.03	5.10
M. bracteata in single strips	11.1	11.9	5.38	6.50	183.46	185.50	4.98	5.01
M. bracteata in double strips.	11.6	12.9	5.15	7.62	184.13	189.30	5.01	5.02
M. bracteata in patches	12.8	13.9	6.94	9.18	194.43	202.70	5.04	5.18
Natural cover	10.8	11.0	4.03	4.48	180.32	187.70	4.96	4.95
SE	0.11	0.08	0.06	0.06	0.93	1.15	0.01	0.02
CD ($P \leq 0.05$)	0.32	0.24	0.19	0.17	2.78	3.46	50.044	0.06

* YAP: Year after planting

Table 4. **Influence of cover crops on fertility status of sub-surface soil (30-60 cm)**

Treatment	Organic carbon (g/kg)		Available P_2O_5 (kg/ha)		Available K_2O (kg/ha)		Soil pH	
	2 YAP	4 YAP	2 YAP	4 YAP	2 YAP	4 YAP	2 YAP	4 YAP*
P. phaseoloides in single strips	10.10	10.60	3.14	3.81	194.70	205.20	5.05	4.99
P. phaseoloides in double strips	10.20	11.20	3.58	4.26	199.10	207.40	5.08	5.06
P. phaseoloides in patches	11.20	12.20	4.70	6.05	201.30	211.70	5.08	5.19
M. bracteata in single strips	9.90	12.20	4.03	4.93	194.60	206.90	5.04	5.03
M. bracteata in double strips.	10.10	11.60	3.58	5.38	196.70	211.60	5.07	5.05
M. bracteata in patches	11.40	12.50	5.15	6.94	201.80	213.90	5.09	5.20
Natural cover	9.70	10.10	2.90	3.36	188.60	188.40	4.99	4.98
SE	0.10	0.07	0.06	0.05	1.00	1.13	0.02	0.035
CD ($P \leq 0.05$)	0.29	0.23	0.19	0.16	3.01	3.40	0.06	0.104

* YAP= Year after planting

The available K content followed a different trend. No significant difference was generally noticed in available K content in surface and sub-surface soils between *M. bracteata* and *P. phaseoloides* established fields under the same planting system. This may be due to the comparatively higher available K in *P. phaseoloides* in spite of its lower production of dry matter. In an experiment to compare nutrient accumulation in *P. phaseoloides* and *M. bracteata* grown in the traditional rubber growing region of India, higher K content was observed for *P. phaseoloides* (Philip *et al.,* 2005 b). However, planting in patches registered significantly higher available K content compared to the other two methods for both the cover crops.

The soil pH of the fields planted with *M. bracteata* in patches (5.04 and 5.18 in the second the fourth years after planting respectively) and *P. phaseoloides* in patches (5.03 and 5.10) were significantly higher than in the fields with natural cover (4.96 and 4.95). The same trend was also seen in the sub-surface soil. Tang and Yu (1999) and Philip *et al.* (2005) observed that addition of plant residues to soil influences the soil pH depending on the concentration of the excess cations/organic anions and nitrogen present in the residues.

Soil moisture

Data on soil moisture content during the stress period (October to March) are presented in Table 5. The mean soil moisture content ranged from 18.98 to 23.74 per cent with the highest for *M. bracteata* planted in patches (23.74 %) followed by *P. phaseoloides* planted in patches (22.86%). Soil moisture content was minimum in the fields under natural cover (18.98 %) and was significantly lower than in all the legume cover treatments. The per cent increase in mean soil moisture content over natural cover ranged from 14.28 to 25.08 in different treatments. Higher moisture content may be attributed to the survival and growth of *M. bracteata* even during stress periods.

Build up of microbial population

The population of fungi, bacteria and actinomycetes in soil was found to be higher in the cover crop fields compared to natural cover (Table 6). The number of fungi in surface and sub-surface soils were found to be higher in *P. phaseoloides* planted in patches followed by *M. bracteata* planted in patches, which were comparable, whereas the population of bacteria was found to be significantly higher in surface soils of *M. bracteata* planted in patches. In the lower layer, the

Table 5. **Soil moisture content (%) during stress period (October- March)***

Treatment	October	November	December	January	February	March	Mean
P. phaseoloides in single strips	25.35	22.19	19.98	19.50	20.01	23.15	21.69
P. phaseoloides in double strips	25.21	21.58	2.77	21.10	21.08	23.65	22.06
P. phaseoloides in patches	25.53	22.96	21.51	21.46	21.18	24.51	22.86
M. bracteata in single strips	24.72	23.27	21.16	21.01	21.01	24.08	22.54
M. bracteata in double strips.	25.74	23.01	21.36	21.15	20.98	23.69	22.66
M. bracteata in patches	26.17	24.41	21.64	22.69	22.16	25.38	23.74
Natural cover	20.72	20.37	17.62	18.16	17.05	20.01	18.98
SE	0.37	0.33	0.062	0.12	0.037	0.062	0.037
CD (P≤0.05)	1.12	0.97	0.19	0.37	0.112	0.186	0.112

* Mean of three years

Table 6. **Distribution of microbial population in soil (end of fourth year)**

Treatment	Surface soil (0-30 cm)			Sub surface soil (30-60 cm)		
	Fungi ($\times 10^3$)	Bacteria ($\times 10^5$)	Actinomycetes ($\times 10^5$)	Fungi ($\times 10^3$)	Bacteria ($\times 10^5$)	Actinomycetes ($\times 10^5$)
P. phaseoloides in single strips	44.29	7.84	5.24	20.26	2.53	1.12
P. phaseoloides in double strips	40.88	7.59	4.31	19.84	2.12	1.43
P. phaseoloides in patches	47.48	8.19	5.61	21.77	3.07	1.99
M. bracteata in single strips	42.36	7.85	4.52	19.41	3.04	1.82
M. bracteata in double strips.	42.67	8.09	4.01	18.23	3.69	1.92
M. bracteata in patches	45.59	8.99	5.95	21.57	3.83	1.95
Natural cover	38.76	6.67	3.79	16.28	2.09	1.05
SE	0.79	0.08	0.23	0.66	0.04	0.04
CD ($P \leq 0.05$)	2.39	0.23	0.70	2.02	0.12	0.13

bacterial population was significantly higher in all *M. bracteata* fields compared to corresponding *P. phaseoloides* fields. The actinomycetes population was found to be the highest in *M. bracteata* planted patches in surface soil. A great variation in the quantitative distribution of microbial population of the soil was noticed which may be due to competition for nutrients. The populations of bacteria and actinomycetes were higher compared to fungal populations. The number decreased with the increase in soil depth. Less aeration, low nutrient availability and low organic matter content at lower depths may be the reasons for the low population.

Litter composition and nutrient accumulation in litter

Nutrient content in the litter of *P. phaseoloides* and *M. bracteata* and nutrient accumulation in soil by the two cover crops are given in Tables 7 and 8. Litter of *M. bracteata* was richer in N and Ca content, and was highest when planted in patches (3.18 % and 1.56 %). The nutrient content was minimum in *P. phaseoloides* planted in single strips (2.65 % and 1.29 %). *P. phaseoloides* litter was richer than that of *M. bracteata* in P, K and Mg contents, the highest being in the treatment where *P. phaseoloides* was planted in patches (0.23 %, 3.31 % and 0.33 % for P, K, and

Table 7. **Nutrient content in cover crop litter (four years after planting)**

Treatment	Nutrient content in cover crop litter (%)				
	N	P	K	Ca	Mg
P. phaseoloides in single strips	2.65	0.21	2.41	1.29	0.27
P. phaseoloides in double strips	2.73	0.22	2.85	1.41	0.28
P. phaseoloides in patches	2.95	0.23	3.31	1.48	0.33
M. bracteata in single strips	2.87	0.18	2.36	1.35	0.24
M. bracteata in double strips	2.95	0.19	2.45	1.48	0.26
M. bracteata in patches	3.18	0.20	2.65	1.56	0.28
Natural cover	—	—	—	—	—
SE	0.016	0.01	0.039	0.021	0.01
CD ($P \leq 0.05$)	0.049	0.031	0.117	0.064	0.031

Table 8. **Nutrient accumulation in soil by cover crop litter (four year after planting)**

Treatment	Nutrient accumulation by cover crop litter (kg/ha)				
	N	P	K	Ca	Mg
P. phaseoloides in single strips	86.52	6.86	78.68	42.11	8.81
P. phaseoloides in double strips	95.88	7.73	100.09	49.51	9.83
P. phaseoloides in 1m² patches	115.14	8.98	129.19	57.76	12.88
M. bracteata in single strips	96.60	6.06	79.44	45.44	8.07
M. bracteata in double strips	106.97	6.89	88.84	53.66	9.43
M. bracteata in 1m² patches	135.25	8.51	112.70	66.35	11.91
Natural cover	—	—	—	—	—
SE	0.19	0.12	0.46	0.25	0.12
CD (P≤0.05)	0.59	0.37	1.42	0.77	0.37

Mg respectively). It was minimum for *M. bracteata* planted for single strip. Similar trend was also observed in the total nutrient accumulation in the litter. The highest nutrient accumulation at the end of the experiment (four years) was observed in the treatment where *M. bracteata* was planted in patches for N (135.25 kg/ha) and Ca (66.35 kg/ha) and *P. phaseoloides* planted in patches for P (8.98 kg/ha), K (129.19 kg/ha) and Mg (12.88 kg/ha). Similar results were also reported by Philip *et al.* (2005).

Growth of *H. brasiliensis*

Cover crop establishment significantly increased the girth and girth increment and dry weight of litter of *H. brasiliensis* as compared to natural cover (Table 9). The values ranged from 23.01to 28.09 cm, 1.85 to 3.05 cm and 2016 to 3058 kg/ha for girth, girth increment and dry weight of rubber litter respectively. The highest girth (28.09 cm), girth increment (3.05 cm) and dry weight of rubber litter (3058 kg/ha) were recorded under the treatment *M. bracteata* planted in patches followed by *P. phaseoloides* planted in patches (27.21 cm, 2.95 cm and 2705 kg/ha.) and the minimum was for natural cover. Similar results were reported by Philip *et al.* (2001; 2005). The improvement in growth of rubber may be due to the beneficial effect of cover crop establishment by nutrient supply through cover crop litter and rubber litter to the soil.

Table 9. **Effect of cover crop on growth of *H. brasiliensiss* and dry weight of rubber litter (four years after planting)**

Treatment	Growth of rubber		Dry weight of rubber litter (kg /ha)
	Girth (cm)	Girth increment (cm)	
P. phaseoloides in single strips	24.89	2.04	2619
P. phaseoloides in double strips	24.83	2.65	2696
P. phaseoloides in 1m² patches	27.21	2.95	2705
M. bracteata in single strips	26.02	2.71	2658
M. bracteata in double strips	26.92	2.90	2672
M. bracteata in 1m² patches	28.09	3.05	3058
Natural cover	23.01	1.85	2016
SE	0.91	0.42	2598
CD (P≤0.05)	1.98	0.91	7768

CONCLUSION

The present study indicated that growing leguminous cover crops *M.bracteata* and *P. phasioloides* in the immature phase of rubber improved the fertility status of soil, microbial population, soil moisture content, accumulation of nutrients and growth of *H. brasiliensis* during its immature phase. Early establishment of the cover crops was noticed when planted in patches.

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