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In situ cultivation and incorporation of green manure legumes in coconut basins

An approach to improve soil fertility and microbial activity

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Summary Nine species of green manure legumes were tested for their ability to grow and establish in basins under coconut. *Pueraria phaseoloides, Mimosa invisa* and *Calopogonium mucunoides* were suitable yielding 19.43, 17.00 and 14.71 kg of green matter per basin. *P. phaseoloides* and *M. invisa* were effectively nodulated with native soil rhizobia as compared to *C. mucunoides.* Green manuring at 20 kg per palm induced a high level of zymogenic response by microorganisms in the coconut rhizosphere. Enzymatic activity in coconut rhizosphere also increased due to green manure addition.

Introduction

Organic manures are important in sustaining soil fertility and productivity especially with a perennial crop like coconut (*Cocos nucifera* L.). Coconut is ideally grown under tropical climatic conditions where the degradation and loss of organic matter from soil is high due to optimal temperature, porous light textured soil type and high precipitation. Application of organic matter like coconut pith, forest leaves and cattle manure enormously improved the growth and flowering in coconut[13]. But due to the non availability of land for cultivating green manures and also the limited supply of cowdung for use as manure, organic manuring is seldom practiced in coconot cultivation. In most coconut growing areas, the interspaces between the palms are cultivated with tuber crops, cocoa, pepper and banana. In this study the possibility of cultivating green manure/cover crops in the basins of coconut was tested. The recommended radius for opening the basins in coconut cultivation is 1.8 m^2 and only this space was utilised without competing for the interspaces which are utilised for raising other crops. Nine green manure/cover crops were tested for their suitability to establish under coconut. The effect of incorporation of the green

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manures generated on the microbiological characteristics of coconut rhizosphere was also studied.

Materials and methods

Establishment of green manures

Two locations were chosen for the study in a sandy soil type on the west coast of Kerala State (India). The coconut palms were 25–30 years old of the variety 'West Coast Tall'. The basins were opened and the following green manure seeds were sown during June, 1981; *Calopogonium mucunoides, Glycine wightii, Leucaena leucocephala, Macroptilium atropurpureum, Macrotyloma axillaire, Mimosa invisa, Pueraria phaseoloides, Sesbania aegiptica* and *Stylosanthes guianensis*. Most of these are tropical forage legume species and some are known to establish well under coconut in the interspaces[16].

The seeds were sown in two concentric circles around the palm within the basin. The seeds of *M. atropurpureum* and *L. leucocephala* were pre-treated by soaking in hot water for 30 min and dried in shade overnight to improve germination and 10–15 g of seeds were sown in each basin in 5 cm deep in furrows. Each legume was sown in the basins of eight palms. Fertilizers at 500 g N, 320 g P_2O_5 and 1200 g K_2O were applied per palm as per the recommended package of practices for coconut[2]. Of this one third was applied during June before sowing of green manure legumes and the rest during September. Weeding of the basins was necessary two months after sowing to encourage better growth of the legumes. The coconut and the green manure crops were not irrigated as the rainfall was well distributed over the period of May–December in this region and the total rain for the period approximated over 1700 mm. Ten weeks after sowing, five plants from each basin were uprooted to study the nodulation status. The plants were harvested after five months and the fresh weight recorded. The nitrogen in plant tops was analysed by the micro-Kjeldahl method after drying the samples at 70°C for four days. The green matter obtained was incorporated in the respective basins.

Microbiological studies in coconut rhizosphere soil

In order to study the effect of green manuring on the microbiological characteristics of coconut rhizosphere soil, green manures were incorporated at the rate of 20 kg per basin. For this study only the green manure crops which established well under coconut were chosen. Soil samples were collected at 0–30 cm depth within the basin one meter away from the base of the palm 10 days after incorporation of the green matter. The soil was collected from four spots in each basin and mixed to obtain a composite sample. The microbial populations were determined following the dilution plate counting technique using soil extract agar, Martin's Rose Bengal agar, Kenknight's agar, Waksman medium 77, Sperber's agar and acidified (pH 6.0) Sperber's agar with streptomycin and Rose Bengal for enumerating bacteria, fungi, actinomycetes, asymbiotic N_2 fixing bacteria, P-solubilizing bacteria and P-solubilizing fungi respectively.

The enzyme activities of the rhizosphere soil samples were determined by the following procedures. Dehyrodgenase activity was assayed by the Triphenyl tetrazolium chloride reduction procedure[5], urease activity by the procedure of Pancholy and Rice[14] except that the ammonia evolved due to urea hydrolysis was estimated by Nesserlization[8]. The phosphatase activity was assayed by using P-nitrophenyl phosphate as the substrate and estimation of P-nitrophenol released[21].

Results

Data on green matter production (tops) and native nodulation status of green manure legumes are presented in Table 1. *Pueraria phaseoloides, Mimosa invisa* and *Calopogonium mucunoides* established well

Table 1. Growth and nodulation of green manure crops in coconut basins

Legume species	Growth		Nodulation	
	Fresh weight (kg/basin)	Total N added (g/basin)	Nodule number/five plants	Nodule dry weight (g/five plants)
Calopogonium mucunoides	14.71	102.61	145	0.485
Macrotyloma axillaire	0.95	6.67	58	0.132
Mimosa invisa	17.00	153.19	125	1.860
Pueraria phaseoloides	19.43	121.29	132	1.128
Leucaena leucocephala	2.95	16.55	0	0.0
Sesbania aegiptica	1.30	6.98	56	0.535
Macroptilium atropurpureum	9.10	66.64	60	0.108
Glycine wightii	2.35	19.20	95	0.205
Stylosanthes guianensis	3.50	12.70	350	0.055
CD at 5%	7.59	53.24	65	2.905

Fig. 1. Growth of *Pueraria phaseoloides* in coconut basin.

under coconuts in the basins, the mean yields obtained being 19.4[3] 17.00 and 14.71 kg/basin respectively. The other legumes did n[o] establish well under coconuts. The growth of *P. phaseoloides* in th[e] basin of coconut palm is shown in Fig. 1. The nitrogen addition to so[il] due to green matter application obtained with *M. invisa, P. phaseoloid[es]* and *C. mucunoides* were 153.19 g, 121.29 g and 102.61 g/basin respe[c]tively.

The native nodulation status of the three green manure crops whic[h] established well under coconut varied considerably. *M. invisa* and *P. phaseoloides* nodulated better at both the locations than *C. mucu[noides.* The nodules were found to be effective in all the three plan[t] species.

Table 2 shows the effect of green manures on microbiological charac[te]ristics of coconut rhizosphere soil. Green manure application resulte[d] in significant increases in the population of specific groups of micro[-] organisms. However, with *M. invisa* a reduction in the populations o[f] bacteria and the number of nitrogen-fixing microorganisms was evident. Comparatively *Pueraria* green manure application resulted in th[e] maximum increase in the population of the different groups of micro[-] organisms.

The data on changes in enzymatic activity of coconut rhizospher[e] soil is given in Table 3. Significant increase in the enzymatic activitie[s] due to green manure application was evident. The response in terms o[f] enzymatic activities was comparatively low with the incorporation of *M. invisa.* Maximum increase in dehydrogenase activity was evident with *Pueraria* treated coconut while with *Calopogonium* phosphatase and urease activities increased considerably.

Table 2. Effect of green manure incorporation on microbial population in coconut rhizosphere soil

Green manure incorporated	Microbial population per g oven dry soil					
	Bacteria ($\times 10^6$)	Fungi ($\times 10^4$)	Actinomycetes ($\times 10^4$)	Asymbiotic N_2 fixers ($\times 10^3$)	P-solubilisers	
					Fungi ($\times 10^3$)	Bacteria ($\times 10^4$)
Pueraria phaseoloides	39.25	8.80	18.78	69.30	7.85	7.51
Calopogonium mucunoides	16.00	11.39	14.67	63.49	4.15	6.16
Mimosa invisa	2.84	10.12	5.27	30.12	6.38	4.47
Control	18.61	2.30	6.86	41.44	1.17	1.75
CD at 5%	10.08	2.75	2.98	NS	2.73	NS

Table 3. Effect of green manure incorporation on enzyme activities in coconut rhizosphere soil

Green manure incorporated	Dehydrogenase activity (μg TPF/g oven dry soil)		Phosphatase activity (μg PNP/g oven dry soil)	Urease activity (μg NH_4^+/g oven dry soil)
	Endogenous	Response to glucose		
P. phaseoloides	4.072	22.226	62.22	93.08
C. mucunoides	3.281	29.550	82.58	97.04
M. invisa	3.310	11.975	54.11	69.75
Control	1.568	5.450	50.93	68.29
CD at 5%	1.411	8.400	14.75	11.41

Discussion

Attempts at growing leguminous crops in coconut basins were not made previously. This study establishes clearly the possibility of growing leguminous cover crops in basins as green manure for coconut. Leguminous crops and grasses have however been tested for their suitability to grow in the interspaces of coconut and Plucknett[16] has reviewed this aspect exhaustively. From this study *P. phaseoloides, M. invisa* and *C. mucunoides* were recognised as suitable crops for cultivation in coconut basins. The other legumes could not establish well under these conditions which may be due to several reasons. Higher light requirement and morphological features of these crops may contribute to this.

Pueraria has been recognised as ideal legume to be grown as a cover crop under coconut in the interspaces[9,12]. Magot and Cadigal[12] testing six different cover crops under coconut found *P. phaseoloides* to yield the highest dry matter of 20.53 tonnes/ha. Much of the previous work relates to the growing of legumes in interspaces under coconut for forage. Our studies are directed towards cultivating the legumes only in the basin spaces to generate organic material *in situ* and augment soil organic matter resources. The application of green manure caused a high level of zymogenic response by the different specific and non specific groups of microorganisms due to the availability of easily decomposable source of energy and carbon. Several workers have found such high spurts in biological activity in soil due to the application of organic matter[6,7,11,19]. The population of asymbiotic nitrogen-fixing bacteria and phosphate solubilizers increased considerably. Increased nitrogen fixation in a straw-soil incubation system has been reported previously[3]. The N_2 fixers and phosphate solubilizers being largely heterotrophic are dependent on the availability of carbon and energy sources for their growth and multiplication in soil. Katznelson[10] stressed the need for examining the possibility of altering the rhizosphere population so as to render the root zone inimical to pathogens. It is now well known that the application of decomposable organic residues will help in suppressing the soil borne plant pathogens[15]. As the rhizosphere microbial load increased significantly due to green manure application there is a distinct possibility of suppressing the root infecting pathogens.

Dehydrogenase, phosphatase and urease activities increased considerably due to the application of the green manures. It has been suggested that the soil enzymatic activities could be considered as better indicators of soil biochemical activities[4,20].

The significant increase in the population of microorganisms and the

enzymatic activity suggest a modification in the soil environment to the benefit of plant growth. The observed effects are contributed by the decomposition of both the green matter added[7,19] and its root system remaining in the basin soil. The degree of response due to Mimosa application was lower as compared to the other two legumes. This is possibly due to the woody nature of the plant residue which may decompose only slowly in soil. The chemical nature of plant residues have a significant effect on their decomposition in soil[7]. The cultivation of fodder grass and leguminous cover crops under coconut was found to improve the microbiological properties as well as the yield of coconut[17].

Maintenance of soil fertility and productivity in the hot humid tropics poses special problems due to the heavy rainfall and soil loss due to erosion. Cultivation of cover crops and using them as green manure is considered effective in checking losses of soil components due to erosion and rapid decomposition in organic matter[1]. The method of cultivating the leguminous crops in coconut basins is simple and inexpensive and with the continuous cultivation of the legumes it is possible to augment soil organic matter resources for sustaining soil fertility and improve coconut yield.

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