

MICROBIOLOGY

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The nature and activities of the micro-organisms in a soil environment depend on the crop grown, infestation by pests/pathogens and management practices. The root surface microflora of the coconut palms in relation to coconut root (wilt) disease have been determined under varying conditions. The pioneering efforts of Radha and Menon (1954) has indicated a consistent reduction in the micro-organisms on the root-surface of root (wilt) affected palms compared to the apparently healthy palms in the disease affected tract. Radha and Rawther (1959) subsequently reported a comparative reduction in the soil microflora during rainy season in the same tract. Rawther and Radha (1963) reported a low soil microbial activity in terms of CO₂ evolved from a unit quantity of soil in unit time.

However, the results of the investigation carried out by Potty (1977) revealed significantly higher population of actinomycetes and bacteria in coconut soils of root (wilt) affected region compared to the healthy (Fig 15). The occurrence of these organisms was higher in the top soil at a depth of 0-25 cm. Irrespective of the diseased condition the coconut rhizosphere harboured higher numbers of actinomycetes, bacteria and fungi (Fig. 16). The number of different microflora was more in the rhizosphere of diseased palms compared to healthy. The difference in the quantitative distribution of

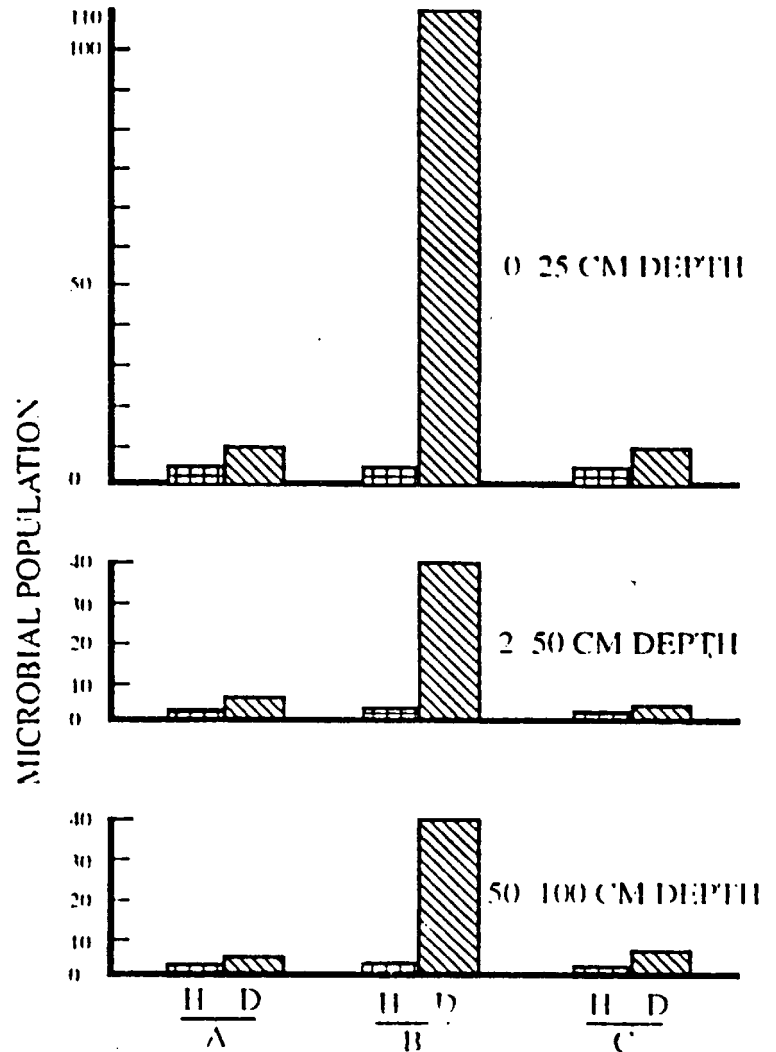


Fig. 15 Distribution of actinomycetes, bacteria and fungi in the healthy and root (wilt) affected regions

- | | | | |
|---|----------------|---|--|
| H | Healthy region | D | Root (wilt) affected region |
| A | Actinomycetes | | (10 ⁴ per g of oven dry soil) |
| B | Bacteria | | (10 ⁶ per g of oven dry soil) |
| F | Fungi | | (10 ⁴ per g of oven dry soil) |

the various micro-organisms between the young and old roots was not consistent. Similarly, the pattern of occurrence of the different microflora in the coconut rhizosphere varied in different soil types irrespective of the disease condition of the

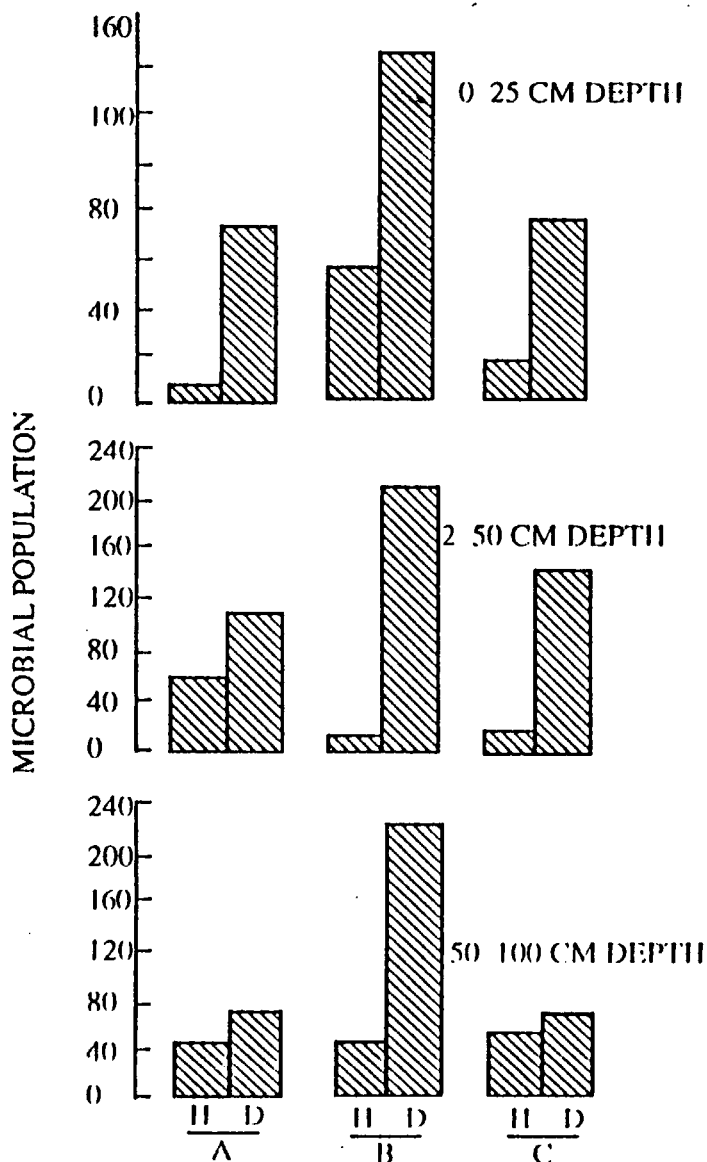


Fig. 16 Distribution of rhizosphere microflora in healthy and root (wilt) affected palms

H Healthy palms D Root (wilt) affected palms
 A Actinomycetes (10³ per g of oven dry soil)
 B Bacteria (10⁶ per g of oven dry soil)
 F Fungi (10⁴ per g of oven dry soil)

palms. Within the root (wilt) affected region a higher population of the different microflora was noticed with higher levels of water table (Fig. 17). This trend was more pronounced in the case of bacteria.

Observations were also recorded on the microflora of the coconut palms under mixed cropping with fodder crops in the root (wilt) affected region. Preliminary studies revealed higher values of total bacteria and ratios of nitrogen fixing organisms to denitrifiers in coconut soils cultivated with the fodder crop *Stylosanthes gracilis* alone and in combination with Hybrid Napier

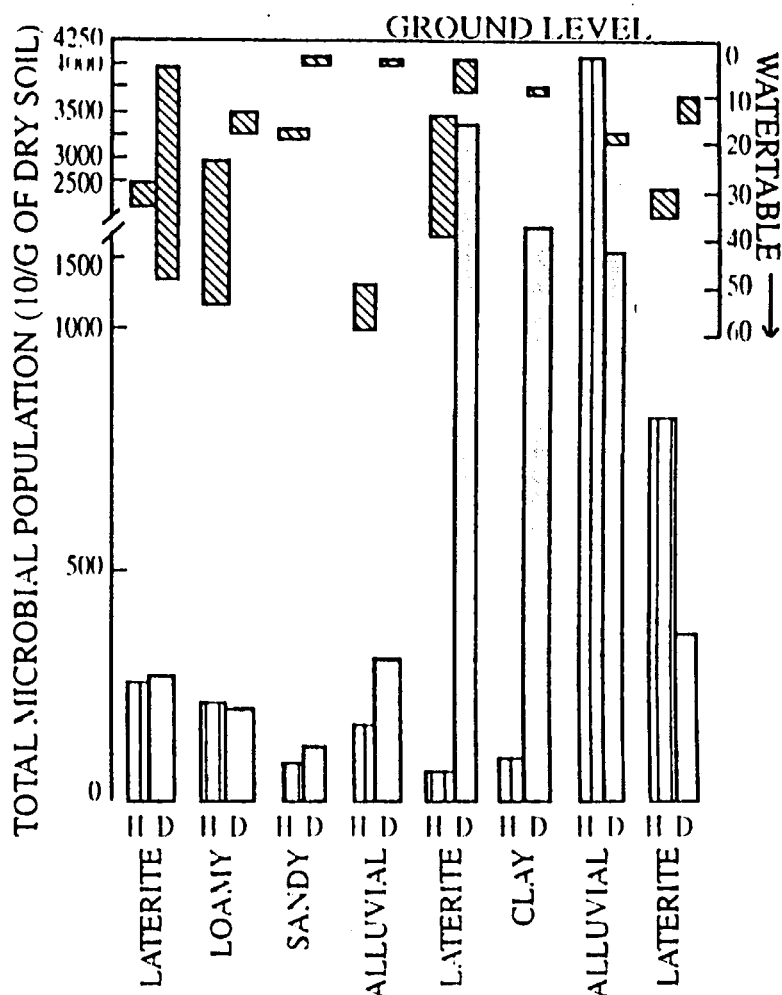


Fig. 17 Distribution of total microflora in relation to water table in healthy and root (wilt) affected regions

H Healthy palms.
 D Root (wilt) affected palms.

(Sahasranaman *et al.*, 1983). Mixed cropping with Hybrid Napier enhanced the total bacteria and nitrogen fixing organisms in the coconut rhizosphere irrespective of the disease condition of the palms. There was also an increase in the number of phosphate solubilising bacteria in the rhizosphere of healthy and diseased palms; but the diseased palms harboured a higher number (Potty *et al.*, 1977). These trends were, however, reversed after the application of inorganic manures (Potty and Jayasankar, 1983) (Table 25). Studies on the influence of growing fodder legumes (*Centrosema pubescens* and *Stylosanthes gracilis*) besides Hybrid Napier on the rhizosphere microflora of the coconut palms showed similar trends.

Physiological classification of the actinomycetes isolated from the root surface

of healthy and root (wilt) affected coconut palms under mixed cropping with Hybrid Napier (Ag. I), *Centrosema pubescens* (Ag. II), and *Stylosanthes gracilis* (Ag. IV) yielded positive indications (Potty, 1977). Traits studied were phosphate solubilisation (P), nitrate reduction (N), cellulose digestion (C), gelatin hydrolysis (G) and starch hydrolysis (S). A distinct difference was noticed in the combinations PG, PS, PC and PN between the crop mixed and control plots. In Ag. III treatments GS, GC and GN combinations were absent in the isolates. In the combination among three different characters, PGS, PGC, PSN and PCN were not observed in any of the isolates from AG. II treatment. The combined ability of all the five characteristics PGSCN was noticed only among the isolates from diseased palms in Ag. I Treatment. Result indicated the possibility of altering

Table 25. Influence of crop mixing Hybrid Napier grass on the coconut rhizosphere microflora, before and after fertilizer application.

Organisms	Coconut + Napier grass				Coconut alone			
	Pre-application		Post-application		Pre-application		Post-application	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
Total								
Bacteria	51.84	21.25	21.83	10.28	27.00	5.51	5.15	7.81
Fungi	37.62	29.46	28.67	206.71	6.76	76.11	1.05	20.48
Nitrogen fixing								
Bacteria	84.20	35.86	9.92	8.25	35.86	8.71	3.47	7.88
Phosphate solubilizing								
Actinomycete	4.95	2.33	0.83	1.30	1.45	3.04	0.33	0.55
Bacteria	8.15	130.78	0.61	0.87	8.85	3.95	0.63	0.93
Fungi	6.58	5.26	1.12	1.21	2.40	2.40	1.52	1.46

the microflora of the coconut rhizosphere by appropriate inter and mixed cropping.

The feasibility of intercropping tuber/rhizome crops with coconut palms in the root (wilt) affected tracts of Kerala has been brought out by Antony (1983). The population of the different microorganisms including nitrogen fixing and phosphate solubilising ones was enumerated during the first and second years at the time of harvest of the intercrops. In addition, enzymatic activities like dehydrogenase, invertase, urease and phosphatase were estimated at the time of planting, during vegetative phase and at harvest during the third year. Beneficial influence on the number of asymbiotic nitrogen fixing bacteria was noticed both in the coconut root surface and non-rhizosphere soils. During the vegetative phase there was a significant increase in the activities of dehydrogenase and invertase. Intercropping significantly stimulated

phosphatase activity in the non-rhizosphere soils.

Thomas and Shantaram (1984) conducted studies to find out the ability of different green manure legumes to grow and establish in the basins of root (wilt) affected coconut palms in sandy loam soils. Among the nine legumes *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides* yielded 19.43, 17.00 and 14.71 kg of green matter/basin, respectively, in a period of four months (Table 26). *In situ* there was a significant increase in the microbial populations as also in the activities of soil enzymes viz. dehydrogenase, urease and phosphatase (Tables 27,28) due to the incorporation of legumes in respective coconut basins.

The biomass production, nitrogen contribution and nodulation characteristics of ten species of legumes were evaluated in

Table 26. Growth and nodulation of green manure crops in basins of root (wilt) affected coconut palms (Thomas and Shantaram, 1984)

Legume species	Growth		Nodulation	
	Fresh weight (kg/basin)	Total N added (g/basin)	Nodule number/five plants	Nodule dry weight (g/five plants)
<i>Calopogonium mucunoides</i>	14.71	102.61	145	0.485
<i>Macrotyloma axillare</i>	0.95	6.67	58	0.132
<i>Mimosa invisa</i>	17.00	153.19	125	1.860
<i>Pueraria phaseoloides</i>	19.43	121.29	132	1.128
<i>Leucaena leucocephala</i>	2.95	16.55	0	0.000
<i>Sesbania aegyptica</i>	1.30	6.98	56	0.535
<i>Macroptilium atropurpureum</i>	9.10	66.64	60	0.108
<i>Glycine weighti</i>	2.35	19.20	95	0.205
<i>Stylosanthes guianensis</i>	3.50	12.70	350	0.055
CD at 5 %	7.59	53.24	65	2.905

a root (wilt) diseased garden in laterite soil type (Thomas and Shantaram, 1993). *P. phaseoloides*, *C. mucunoides* and *M. invisa* yielded higher quantities of biomass to the level of 28.4, 27.2 and 24.9 kg per basin with a nitrogen contribution of 196.2, 186.5 and 187.6 g per basin, respectively, during a growth period of 130-140 days in rainy season. Zymogenic response of microflora and enhanced dehydrogenase enzyme activities were observed in root region soils of coconut at maximum vegetative growth of legumes

in coconut basins and at 30 days of incorporation of green manures (Thomas, 1987). *In situ* cultivation and incorporation of legumes were also effective in enhancing the vesicular-arbuscular mycorrhizal (VAM) symbiosis in coconut.

Subsequently, Thomas (1988) reported the adverse effect of root (wilt) disease on the mycorrhizal symbiosis of coconut and showed the efficacy of intercropping system with hybrid napier in increasing the

Table 27. Effect of green manure incorporation on microbial population in coconut rhizosphere soil (Thomas and Shantaram, 1984)

Green manure incorporated	Microbial population per g oven dry soil					
	Bacteria (X10 ⁵)	Fungi (X 10 ⁴)	Actinomycetes (X10 ⁴)	Asymbiotic N ₂ fixers (X10 ³)	P. solubilisers	
					Fungi (X10 ³)	Bacteria (X10 ⁴)
<i>P. phaseoloides</i>	39.25	8.80	18.78	69.30	7.85	7.51
<i>C. mucunoides</i>	16.00	11.39	14.67	63.49	4.15	6.16
<i>M. invisa</i>	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 28. Effect of green manure incorporation on enzyme activities in coconut rhizosphere soil (Thomas and Shantaram, 1984)

Green manure incorporated	Dehydrogenase activity (µg TPF/g over dry soil)		Phosphatase activity (µg PNP/g oven dry soil)	Urease activity (µg NH ₄ ⁺ /g oven dry soil)
	Endogenous	Response to glucose		
<i>P. phaseoloides</i>	4.072	22.226	62.22	93.08
<i>C. mucunoides</i>	3.281	29.550	82.58	97.04
<i>M. invisa</i>	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

TPF = Triphenylformazo; PNP = Para nitrophenol

mycorrhizal status of root (wilt) affected coconut palms.

The field trial conducted with *P. phaseoloides*, *M. invisa* and *C. mucunoides* for a period of five years indicated the effectiveness of basin management with the legumes along with the application of recommended dose of NPK and MgO in increasing the productivity of root (wilt) diseased palms without causing further deterioration in the disease condition of the palms (Thomas *et al.* 1993).

Inoculation studies on *P. phaseoloides* and *C. mucunoides* with eight isolates of *Rhizobium* from different forage legumes indicated the promiscuous nature of rhizobium requirement of the two legumes (Thomas and Shantaram, 1987). A comparative field trial with promising local isolates of *Rhizobium* and NifTAL cultures

in a root (wilt) diseased coconut garden indicated the effectiveness of composite NifTAL cultures in increasing nodulation and dry matter production in *C. mucunoides*. *P. phaseoloides* did not respond to rhizobial inoculation due to effective nodulation by native soil rhizobia. *M. invisa* also showed profuse nodulation by native rhizobia in different soil types.

Cropping systems involving inter cultivation of crops resulted in an improvement in the microbial population and biological activities in the root region soils of root (wilt) diseased coconut palms indicating a modification in the soil environment to the benefit of plant growth. The cultivation and incorporation of green manure legumes in coconut basins can be considered a simple and less expensive input to enhance the soil fertility and yield of diseased palms.

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