

# INFLUENCE OF DIFFERENT CROPPING SYSTEMS IN COCONUT ON BENEFICIAL MICROORGANISMS AND BIOLOGICAL ACTIVITIES OF THE SOIL

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The intensive cropping systems involving coconut are essentially crop combinations which envisage the cultivation of other compatible crops in the interspaces between the palms. The crops chosen vary depending upon the agro climatic regions. The biological interaction involving microorganisms, insect pests and plant pathogens are of considerable importance in crop combination. The activity of rhizosphere and root region micro organisms can affect the uptake of nitrogen, phosphorus and other micronutrients in plants. The proliferation of *Beijerinckia*, *Azetobacter* and *Azospirillum* can increase the nitrogen availability, whereas the Vesicular-Arbuscular (VA) mycorrhizal colonisation can benefit the plant by increasing the uptake of phosphorus, zinc and copper. The inhibition potential of phytopathogens of soil is likely to be higher in mixed cropping than in

sole crop. The influence of different coconut based cropping systems such as mixed cropping, mixed farming, multistoreyed cropping, high density cropping and agroforestry systems on beneficial microorganisms and biological activities in soils are discussed under different headings.

## Influence of Mixed Cropping

Some tree crops and other perennials which require or tolerate shade are grown as mixed crops. These crops include cocoa, clove, nutmeg and coffee. Growing of cocoa in the interspaces of coconut is being practiced in Philippines, Malaysia, India and New Guinea. The number, nature and specific biological attributes of bacteria, fungi, actinomycetes,  $N_2$ -fixers, P-solubilizers and indole acetic acid (IAA) producing microorganisms was found increased in the rhizosphere of coconut under mixed cropping with cocoa as compared to coconut monocrop

(Table 1). The production of gibberellin like substances (GLS) was detected by chromatographic and bioassay methods. Further, in this system there is a sizeable addition of organic matter into the soil by shed leaves and it helps in organic recycling and suppression of weed growth in the garden. *Beijerinckia* and *Azospirillum* are  $N_2$ -fixers encountered in the system and *Pseudomonas* spp. *Bacillus* spp. *Aspergillus* spp. and *Pencillium* spp. are the phosphate solubilizers. The bacteria, *Escherichia* sp. was found associated with the root surface of coconut and it produced indole acetic acid (IAA) in the culture medium. The growth and yield of coconut with cocoa indicated that both the species are compatible as mixed crop. In addition to compatibility, the 'synergistic' effect of increase in yield of coconut palm was recorded.

## Influence of Multistoreyed and High Density Multispecies Cropping

In this cropping system, the crop combinations involve annuals and perennials. This cropping systems represent the most intensive type of land management and it is possible only under irrigation. The crop combinations of coconut with black pepper, cocoa and pineapple or coconut with cinnamon, pepper and pineapple are the typical multi-storeyed cropping systems. Among these combinations, the former was found biologically

**Table 1. Microbial population in the rhizosphere of coconut cocoa mixed cropping and coconut alone cropping system (CFU g<sup>-1</sup> Soil)**

Cropping system and crop	Bacteria (x10 <sup>6</sup> )	Fungi (x10 <sup>4</sup> )	Actinomycetes (x10 <sup>6</sup> )	Beijerinckia (x10 <sup>3</sup> )	P-solubilizer (x10 <sup>4</sup> )
A. Coconut-cocoa system					
Coconut	160	39	3	6	3
Cocoa	128	18	4	14	5
B. Coconut Mono-cropping system					
Coconut	104	15	2	2	2

(Nair and Subba Rao, 1977)

**Table 2. Soil microflora and beneficial microorganisms in the root zone of coconut based multistoreyed, high density multispecies and coconut monocropping system (CFU g<sup>-1</sup> soil)**

Cropping system and crop	Bacteria (x10 <sup>5</sup> )	Fungi (x10 <sup>3</sup> )	N <sub>2</sub> -fixers (x10 <sup>3</sup> )	P-solubilizers (x10 <sup>4</sup> )
I. A. Coconut multistoreyed cropping system: <sup>4c</sup>				
Coconut	21.1	32.3	8.8	3.5
Cocoa	14.5	42.6	12.1	5.2
Pineapple	12.4	26.7	10.2	8.0
B. Coconut mono-cropping system				
Coconut	6.4	13.7	6.0	2.7
II A. Coconut based high density multispecies cropping system: <sup>3*</sup>				
Coconut	14.6	16.5	8.6	4.2
Banana	21.0	13.6	--	--
Pineapple	19.5	11.2	14.6	3.4
Clove	15.0	8.6	9.7	3.8
B. Coconut mono-cropping system				
Coconut	4.6	14.4	5.8	3.0

\* Bopaiah and Shetty, 1991a

\*\* Bopaiah, 1993.

more active. In multistoreyed and multispecies cropping system, the bacteria, fungi, N<sub>2</sub>-fixers and P-solubilizers (bacteria) were higher as compared to coconut monocropping (Table 2). The microbial counts and biological activities decreased with increase in depth of soil and it was least in 51-100cm depth. The compatible crops develop congenial conditions for the rapid proliferation of microorganisms in soil.

The urease, dehydrogenase and phosphatase enzyme activities in the root region soils of various crops in the cropping system showed variations indicating the rhizosphere effect. The VA-mycorrhizal colonisation was to the extent of 58-90 percent in various crops. Soil microbial biomass was higher in the multistoreyed and multispecies cropping system as compared to coconut monocropping. The continuous addition of plant residue

by the component crops and the organic matter recycling facilitates the cropping system to exert a favourable influence on microflora and microbiological activities.

## Influence of Mixed Farming

The fodder crops are important for the maintenance of dairy and other farm animals in the coconut growing areas. The grasses such as hybrid napier-NB-21, Pusa Giant, Guinea grass and the legumes, *Stylosanthes gracillis* and *Centrocema pubescens* proved better in coconut garden. The coconut based mixed farming with fodder grass (hybrid napier, NB-21) in a 70 year old coconut garden increased soil microflora, N<sub>2</sub>-fixers, microbiological activities and fertility parameters as compared to coconut monocropping system (Table 3). The cultivation of fodder grasses (hybrid napier) and legumes like *Stylosanthes graimmensis* and *Centrocema pubescens* enhances the population of total bacteria, nitrogen fixing, phosphate solubilizing and indole producing microorganisms in the root region of coconut (Table 3). The mixed cropping favoured the proliferation of nitrogen fixers of which *Beijerinckia* was the predominant. The crop mixing also showed the difference in the occurrence of physiologically distinct actino-

**Table 3. Microflora and beneficial microorganisms in the root zone soils of coconut mixed farming and coconut monocropping system (CFU g<sup>-1</sup> soil)**

Cropping system and crop	Bacteria (x10 <sup>6</sup> )	Fungi (x10 <sup>3</sup> )	N <sub>2</sub> -fixers (x10 <sup>4</sup> )	P-solubilizers	
				Bacteria (x10 <sup>4</sup> )	Fungi (x10 <sup>3</sup> )
A. Coconut-mixed farming - Kasaragod <sup>*</sup> Expt.					
Coconut	8.0	9.3	21.4	18.3	4.3
Napier grass	8.7	3.2	38.7	12.7	1.8
Coconut-mono-cropping					
Coconut	2.3	2.3	10.7	5.7	2.7
B. Coconut-mixed farming Expt. Kayangulam <sup>**</sup>					
Coconut + Napier grass	51.8	37.6	84.2	8.2	6.6
Coconut alone (mono crop)	27.0	6.8	38.9	8.5	2.4

\* Root zone soil - Bopaiah and Shetty, 1991b

\*\* Rhizosphere soil - Potty and Jayasankar, 1976.

mycetes in the rhizosphere of coconut. The carbon and nitrogen mineralisation rates were greater in the root region soils of coconut mixed farming system. The addition of organic matter to soil increases the carbon mineralisation rate by 3-4 fold. The root region soils of coconut recorded higher microbial biomass in soil as compared to coconut monocrop. The occurrence of *Azospirillum* was recorded in the roots of coconut and napier grass. In the mixed farming system (coconut-hybrid napier grass) increased VA-mycorrhizal colonisation was recorded (73-79 per cent) as compared to coconut monocropping system (60 per cent).

### Influence of Coconut Based Agro-forestry System

Growing tree species such as *Eucalyptus*, *Leucaena*, *Casuarina* and *Ailanthus* in the interspace of coconut (7.5m x 7.5m spacing) in three rows at 1m spacing under rainfed condition has shown deleterious effect on soil microflora including  $N_2$ -fixers,

P-solubilizers (Table 4) and soil enzyme activities in the root zone soils of coconut. The soil pH and organic carbon (%) also decreased considerably as compared to coconut monocropping.

Soil fertility depends to a large extent on the microbial profile of the soil. The greater volume of roots of the crops per unit volume of soil adds more organic matter by way of dead roots. The effect of crop combination on agro-ecological factors such as light, soil micro-organisms, climate and the physical aspect of input management affect the productivity of the crops. Thus several crops have been found as compatible except for the tree species (Agro-forestry) with coconut which improves the microbiological, soil fertility and biological productivity of the cropping system. Some microorganisms (bacteria, fungi and actinomycetes) have shown antagonistic properties against *Phytophthora palmivora* under *in vitro* condition. Further it is

possible to exploit the  $N_2$ -fixers (*Beijerinckia* and *Azospirillum*), phosphate solubilizing bacteria and VA-mycorrhizae occurring in the rhizosphere of coconut in the nitrogen and phosphorus nutrition of coconut palm by using it as biofertilizer either in the nursery inoculation or while field planting or under both occasions. The microorganism selected should have wider adaptability to the diverse soil conditions and also able to compete with the native microbes for its survival and activity in soil.

### References

Bopaiah, B.M. 1987. Microbiological and biochemical studies in relation to high density multispecies cropping *CPCRI Annual Report*, 1987 pp 30-31.

Bopaiah, B.M. 1993. Microbiological and biochemical studies in relation to high density multispecies cropping system. *CPCRI Annual Report 1992-93* pp 44-45.

Bopaiah, B.M. and Sheker Shetty, H. 1991a. Soil microflora in root region of coconut-based multistoreyed cropping system. *Soil Bio. and Biochemi* 23: 89-94.

Bopaiah, B.M. and Sheker Shetty, H. 1991b. Microbiology and fertility of coconut based mixed farming and coconut monocropping systems. *Trop. Agric.* 68: 135-138.

Nair, S.K. and Subba Rao N.S. 1977. Microbiology of the root region of coconut and cocoa under mixed cropping. *Plant and Soil*. 46: 511-519.

Potty, V.P. and Jayashankar, N.P. 1976. Influence of crop mixing of hybrid-napier on the root zone microflora of the coconut palm. *In coconut research and Development* (Ed) N.M. Nayar. Wily Eastern Ltd, New Delhi pp 300-303.

**Table 4. Soil microflora and beneficial microorganisms in the root zone soils of coconut based agro-forestry and coconut monocropping systems (CFU g<sup>-1</sup> soil)\***

Cropping system and crop	Bacteria (x10 <sup>5</sup> )	Fungi (x10 <sup>3</sup> )	$N_2$ -fixers (x10 <sup>3</sup> )	P-solubilizers (x10 <sup>4</sup> )
<b>A. Coconut based Agro-forestry:</b>				
1. Coconut	24.1	11.1	2.1	5.1
Eucalyptus	8.8	11.9	2.9	5.3
2. Coconut-Casuarina				
Coconut	30.5	8.7	8.5	4.5
Casuarina	23.4	5.6	14.3	3.7
3. Coconut-Leucaena				
Coconut	18.3	10.2	6.4	3.6
Leucaena	12.3	8.6	4.0	3.0
4. Coconut-Ailanthus				
Coconut	22.8	13.2	5.4	4.8
Ailanthus	8.5	15.8	3.1	4.2
<b>B. Coconut monocropping system</b>				
Coconut	44.4	14.9	9.6	7.9

\* Bopaiah, 1987