BENEFICIAL MICROORGANISMS IN THE ROOT REGION SOILS OF COCONUT PALM UNDER DIFFERENT CROPPING SYSTEMS - A REVIEW

by

B. M. Bopaiah*

The coconut palm is amenable to intensive crop combinations at most periods of its life and great possibilities exist for increasing the agricultural production through intensive cropping in coconut areas. Coconut palms are grown under diverse soil conditions ranging from littoral sands to clayey soils (Menon and Pandalai, 1960). In pure stand of coconuts at normal planting (7.5 x 7.5 m) density and management conditions, about 75% of the area is not being effectively utilised to the fullest extent by coconut roots (Kushwah et al. 1973). The intensive cropping system involving coconuts are essentially crop combinations which envisage the cultivation of other compatible crops in the interspaces between the palms. Depending upon the duration of additional crops, so grown, the system shall be considered as inter, mixed, multi-storeyed or multispecies cropping. The crops chosen vary from tract to tract (Nelliat and Shama Bhat, 1979).

The nature and activity of microflora and fauna in a given environment depends upon the crop grown and the management practices (Clark, 1949). The nature of microorganisms associated with perennials such as tree crops likely to be almost constant, but the introduction of other annual or perennials could change this equilibrium and in turn could be either beneficial or detrimental for the crop community. Biological interactions involving micro-organisms, insect pest and plant pathogens are of considerable importance in crop combination. The activity of rhizosphere and root region microorganisms can affect the nutrient uptake (Bowen and Rovira, 1968; Nair and Rao, 1977) and the wide range of organic compounds known to be present in the rhizosphere (Rovira 1965; Stevenson, 1967) can influence the growth of plants. The VesicularArbuscular (VA) mycorrhizal colonisation benefits the plant by increasing the uptake of phosphorus, zinc and copper, and it also helps in drought tolerance in crop plants. The inhibitation potential of phytopathogens of soil is likely to be higher in mixed cropping than in a sole crop. The work on the influence of coconut based intercropping, mixed cropping, mixed farming, multistoreyed cropping, high density multi-species cropping and agro-forestry systems on microflora and microbiological process in soil are discussed under different headings.

Influence of Intercropping

Several intercrops such as root and tubers (Cassava, elephant foot yam, greater yam and sweet potato), rhizomes species (ginger and turmeric), grain legumeB (green gram, black gram, horse gram, cowpea, groundnut and soybean) and others like upland rice, banana and pineapple could be successfully grown in coconut plantation (Nelliat and Shama Bhat, 1979).

---

*Central Plantation Crops Research Institute Kasaragod 671 124, Kerala, India.

The intercropping with fodder grasses (hybrid napier) and legumes like *Stylosanthus graimmensis* and Centrosema pubescens enhances the microbial activity in the root region of coconut (Potty et al., 1977). The population of total bacteria, nitrogen fixing microorganisms to denitrifiers were more in the root region of coconut intercropped with fodder legume, *Stylosanthus gracilis* alone and in combination with hybrid napier, NB-21 and pusa gaint (Sahasranamen et al., 1976). Similarly, the intercrops in healthy and root (wilt) affected coconut gardens with hybrid napier increased the total bacteria, N_2- fixers and prosphate solubilizing bacteria (Potty et al, 1977). Potty (1977) reported that crop mixing with Centrosema pubescens and *Stylosanthus gracilis* besides hybrid napier increased the number of fungi, bacteria, actinomycetes and indole producing microorganisms in coconut rhizosphere. The mixed cropping also favoured the proliferation of nitrogen fixing micro-organisms, of which *Beijerinckia and Azotobactez* were the predominant *nitrogen fixers*. The physio-chemical factors of coconut of rhozosphere like Zk pH, organic carbon, *nitrogen a*nd phosphorus showed correlation with the microflora. The crop mixing showed the difference in the proliferation of physiologically distinct actinomycetes in the rhizisphere of coconut (Potty, 1977).

Influence of mixed cropping

Some tree crops and other perennials which requires or tolerate shade are grown as mixed crops. These crops includes cacao, clove, nutmeg and coffee. Growing of cacao in the interspaces of coconut is being practised in the Philippines, Malaysia, India and New Guinea. The number, nature and specific biological attributes of bacteria, fungi and actinomycets in the rhizosphere of coconut under mixed cropping with cocoa nas been studied (Nair and Rao, 1977a). The N_2-fixers, P-solubilizers and indole acetic acid (IAA) producing microorganisms isolated from rhizosphere soils were estimated quantitatively. The production of gibberellin like substances (GLS) were detected by chromatographic and bioassay methods. An intensive microbial activities in the rhizosphere of coconut with cocoa as mixed crop was recorded in both single or double hedge planting of cacao. Further, in this system there is sizeable addition of organic residues in to the soil in the form of shed leaves and it helps in organic recycling and suppression of weed growth in the garden.

The dominant nitrogen fixing bacteria in the Rhizosphere and root region of coconut were *Beijerinckia s*pp. (Nair and Subba Rao, 1977a, Bopaiah, 1988a). Among the phosphate solubilizing microorganisms, *Pseudomonas* sp., *Bacillus* Sp., *Aspergillus s,. and Penicillum sp.* showed higher solubilization of tricalcium phosphate in-vitro (Nair and Subba Rao 1977b).

The bacteria, *Escherichia s*p. was found associated with the root surface of coconut and it produced indole acetic acid (IAA) in culture medium. Further the analysis of growth and yield of coconut with cacao indicates that both the species are compatible as mixed crop. In addition to compatibility, the “synergistic" effect of increase in yield of coconut palms was recorded (Nair and Subba Rao, 1977a).

Multistoreyed and high density multispecies cropping

System:

In both the cropping systems, the crop combinations involves annuals and perennials with an existing stand of perennial. The multistoreyed or multispecies cropping represents the most intensive type of land management and it is possible only under irrigated conditions. The crop combinations of coconut with black pepper, cacao and pineapple or coconut with cinnamon, pepper and pineapple are the typical multistoreyed cropping systems. Among these combinations, the coconut with pepper, cacao and pineapple was found biologically more active (Bopaiah 1988a).

In the multistoreyed cropping system, the population of bacteria, fungi, N_2-fixers and P-solubilizers (bacteria) were significantly higher as compared to coconut monocropping (Bopaiah and Shetty, 1991a). The pepper, cinnamon, cacao and pineapple in this system have increased the population of asymbiotic N_2-fixers and phosphate solubilizers in the root region (Bopaiah, 1986). In general the population of microorganisms and biological activities decreased with increase in depth of soil and it was least in 51-100 cm depth. The microflora around the living roots are distinctly different from that of non-rhizosphere soil as the plant creates a unique subterraneous habitat for the micro-organisms. When compatible crop combinations like cacao or cinnamon + pepper + pineapple are introduced in a coconut garden, congenial conditions develops 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 system showed variations indicating the rhizosphere effect. VA-mycorrhizal colonisation was to the extent of 58-70 per cent in various crops of multistoreyed cropping system (coconut, cinnamon, pepper, cacao and pineapple). Soil microbial biomass was higher in the multistoreyed cropping system as compared to monocropping system. The continuous addition of plant residue by the component crops and the organic recycling facilitated in the multistoreyed cropping system exert a favourable influence on microflora and microbiological activities in soil. In the high density multispecies cropping model in Kasaragod, higher biological activities was recorded as compared to coconut monocropping (Bavappa et al., 1986).

Mixed farming

The fodder crops are important for diary and other farm animals in the coconut growing areas. The grasses and legumes can be grown in the interspaces of coconut. The grasses such s hybrid napier, NB-21, pusa giant, Guinea grass and the legumes *Stylosanthes gracilis* and *Centrosema pubescens* proved better in coconut garden (Nayar and Sahasranam, 1979). A favourable alternation was observed in the soil microflora and microorganisms colonising the rhizoplane of coconut (Potty and Jayshankar 1976).

The coconut based mixed farming experiment with fodder grass (hybrid napier, NB-21) in a 72 year old coconut garden increased soil microflora, N_2-fixers, microbiological activities and fertility parameters as compared to coconut monocropping system (Bopaiah, 1987; Bopaiah and Shetty, 1991b) . The studies revealed a significant increase in bacteria, fungi, N_2- fixer, Beijerinckia spp) P-solubilizers (bacteria and fungi) counts in the root region of coconut and napier grass of mixed farming system as compared to coconut monocropping. Carbon and nitrogen mineralisation rates were greater in the root region soil of coconut mixed farming system. The addition of glucose or cellulose (0.5%) to soil increases the carbon mineralisation rate by 3-4 fold. The root region soils of coconut recorded higher microbial biomass (187.8 g C/g) soil as compared to coconut monocrop (112 C/g soil) . The Beijerinckia spp. obtained from coconut mixed farming system have greater N2-ability fixing (9-12.5 mg/g sucrose) as compared to coconut monocropping Bystem (5.6 - 9.6 mg/g sucrose). The occurrence of Azospirillum has been reported in the roots of coconut and napier grass by 2, 3, 5 triphenyl tetrazolium test and culturing root bits in N_2-free semi-solid malate medium (Bopaiah 1988a; Ghai and Thomas 1989). The mixed farming system (Coconut-Napier grass) has significantly increased the VA-mycorrhizal colonisation (73-79 percent) as compared to coconut monocropping system (60 percent) (Bopaiah, 1988).

Coconut based Agro-forestry system

Growing tree species such as Eucalyptus, Leucaerea, casuarina and Ailanthus in the interspace of coconut (7.5 m x 7. 5m spacing) in three rows of 1 m spacing under rainfed condition have shown deleterious effect on soil microflora including N_2-f ixers, Psolubilizers and soil enzyme activities in the root zone soils of coconut (Bopaiah, 1988b). Soil pH and organic carbon (%) also

decreased considerably as compared to coconut monocropping. The soil phenol content increased in the root zone soils of coconut in the agro-forestry system.

Soil fertility depends to a large extent on the microbial profile of the soil. When crop mixing or mixed farming is introduced in coconut garden, congenial conditions develops for the multiplication and the activities of microorganisms in soil. The continuous addition of the plant residues by the component crops and organic recycling facilitated by crop mixing or mixed farming to exert a favourable influence on the microbiological activities in the rhizosphere and root zone of the crops. 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 of agro-ecological factors such as light, soil microorganisms, climate etc. and the physical aspect of input management which effect the productivity of the crops. Thus several crops have been found as compatible to grow with coconut which improves the microbiological, soil fertility and biological productivity of the cropping system.

ACKNOWLEDGMENT

The author is grateful to Dr. M. K. Nair, Director and Dr. V. Rajagopal, Head, Division of Physiology, Biochemistry and Microbiology, CPCRI, Kasaragod for their encouragement.

Reference

ANONYMOUS, 1976. Final report of the agrostology Project 1970-1975, CPCRI Regional Station, Kayangulam, Kerala.

BAVAPPA, K. V. A., KAILASAM, C., KHADER, K.B.A., BIDDAPPA, C. C., KHAN, H. H., KASTURI BAI, K. V., RAMADASAN, A., SUNDARARAJU, P., BOPAIAH, B. M., THOMAS G. V., MISHRA, L. P. : BALASIMHA, D., BHAT, N.T. AND SHAMA BHAT, 1986. Coconut and arecanut based high density multispecies cropping systems. J. Plant Crops. 14 : 74-87.

BOPAIAH, B. M. 1986. Asymbiotic N 2- fixers in coconut and Arecanut cropping systems. Workshop on beneficial microbes in Tree Crop Management 8-9 September 1986, CPCRI, Kasaragod, India.

BOPAIAH, B. M. 1987. Benef icial microorganisms in the root region soils on coconut based mixed farming system. VII, Southern Regional Conference on Microbial Inoculants. 25-26 June 1987, UAS Bangalore, India (abstract).

BOPAIAH, B. M. 1988A. Microbiological studies in relation to high density multispecies cropping systems in coconut. Ph.D. Thesis, University of Mysore, Mysore p. 168.

BOPAIAH, B. M. 1988B. Microbiological and biochemical studies in relation to high density multi-species cropping system. CPCRI, Annual Report for 1987 pp. 30-31.

BOPAIAH, B. M. AND SHETTY, H. S. 1991a. Soil microflora and biological activities in the rhizosphere and root region of coconut based multistoreyed cropping systems. Soil Bio. and Biochem. 23 : 89-94.

BOPAIAH, B. M. AND SHETTY, H. S. 1991b. Microbiology and fertility of coconut based mixed farming and coconut monocropping systems. Trop. Agri. 68: 135-138.

BOWEN, G. D. AND ROVIRA, A.D. 1968. The influence of microorganisms on growth and metabolism of plant roots. In W. J. Whittington (ed). Root growth, 170-201 Butterworths, London.

CLARK, F. F. F. 1949. Soil microorganisms and plant roots. Adv. Agron. 1: 241-288.

GHAI, S. K. AND THOMAS, G. V. 1989. Occurrence of Azospirillum spp. in coconut based farming systems. Plant and soil. 114: 235-247.

KUSHWAH, B. L., NELLIAT, E. V., MARKOSE, V. T. AND SUNNY, A.F. 1973. Rooting pattern of coconut (Cocoa nucifera L.) Indian J. Agron. 18: 71-74.

MENON, K. P. V. AND PANDALAI, K. M. 1960. The coconut palm a Monograph, Indian Central Coconut Committee. Ernakulam, India.

NAIR, S. K. and SUBBA RAO, N. S. 1977a. Microbiology of the root region of coconut and cocoa under mixed cropping. Plant and soil 46:511-519.

NAIR, S. K. and SUBBA RAO, N. S. 1977B. Distribution and activity of phosphate solubilizing microorganisms in the rhizosphere of coconut and cocoa under mixed cropping. J. Plant Crops. 5 : 67-70.

NAIR, S. K. and SUBBA RAO, N. S. 1978. Occurrence of fungi in the coconut rhizosphere and rhizoplane and interaction among them. J. Plant Crops 6 : 96-97.

NAYAR, T. V. R. and SHAHASRANAMAM, K. N. 1979. Mixed farming in coconut gardens Root (wilt) affected tract. Nelliat E. V. and Shama Bhat (Ed.). Multiple cropping in coconut and arecanut gardens. Tech. Bull. CPCRI Kasaragod, India pp. 47-49.

NELLIAT, E. V. and SHAMA BHAT, K. 1979. Multiple cropping in coconut and arecanut gardens. Tech. Bull. Series 3. Central Plantation Crops Research Institute, Kasaragod, India.

POTTY, V. P. 1977. Rhizosphere microflora of coconut palm with special reference to root (wilt) disease. Ph.D. Thesis University of Kerala, India.

POTTY, V. P. AND Jayashankar, N. P. 1976. Influence of crop mixing of hybrid napier on the root zone microf lora of coconut palm. In coconut research and development (ed.) NM Nayar, Willey Eastern Ltd. New Delhi. pp. 300-303.

POTTY, V. P. MATHEW GEORGE AND JAYASHANKER, N. P. 1977. Effect of crop mixing on the coconut rhizosphere. Indian Coconut J. 8 : 1-2.

ROVIRA, A. D. 1965. Plant root exudates and their influence upon soil microorganisms. In K. F. Baker and W. C. Snyders (ed) . Ecology of soil borne pathogen p. 70-186. University of California Press. Berkely, California.

SAHASRANAMAM, K. N., PILLAI, N. G. JAYASHANKAR, N. P., POTTY, V. P., THOMAS VARKEY, KAMALASHIAMMA, P. G. AND RADHA K. 1976. Mixed farming in coconut garden. Economics and its effect on root (wilt) disease. In coconut research and development (Ed) . NM NAYAR, WILLY Eastern Ltd., pp. 160-165.

STEVENSON, F. J. 1967. Organic acids in soil. A. D. Mc LAREN and G. H. PETERSON (Ed). 199-146. Soil Biochemistry, Marcel Dekker, New York.