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Floor Crop Nutrition on Microbial Interactions in Coconut Based Multitier Cropping System

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ABSTRACT

To assess the importance of maintaining and improving the soil quality, an understanding of microbial population is of great importance. With the objective to assess the effect of different coconut-based crop combinations and floor crop nutrition on soil quality a study was conducted at Coconut Research Station, Balalaramapuram. Enumeration of bacteria, fungi and actinomycetes from the soils of different coconut-based cropping system under 75 per cent and 100 per cent RDF for the floor crop revealed significant differences in microbial population among the crop combinations and floor crop nutrition. Among the different crop combinations, the bacterial and actinomycetes population was significantly higher (16.7×10^6 CFU g^{-1} wet soil and 6.7×10^4 CFU g^{-1} wet soil respectively) for coconut + banana + turmeric system and the fungal population was higher (2.6×10^3 CFU g^{-1} wet soil) for coconut + banana + ginger system. Results clearly revealed that, compared to papaya, treatments, involving banana resulted in higher population of bacteria, actinomycetes and fungi. Application of 75 per cent recommended dose of fertilizers (RDF) for the floor crop resulted in higher microbial population. Interaction effect was also significant and coconut + banana + turmeric system with 75 per cent RDF for the floor crop turmeric (c_1n_2) recorded significantly higher bacterial (18.0×10^6 CFU g^{-1} wet soil) and actinomycetes (7.0×10^4 CFU g^{-1} wet soil) population while fungal population (3.1×10^3 CFU g^{-1} wet soil) was higher for coconut + banana + ginger system with 75 per cent RDF for the floor crop ginger (c_2n_2). It can be concluded that, 75 per cent RDF for the floor crop was sufficient for maintaining the soil microbial population in high density multiple cropping system in coconut.

***Key words**: Actinomycetes, Bacteria, Coconut, CFU, Fungal, Recommended dose of fertilizers (RDF)*

Introduction

Soil microorganisms assume a significant part in nutrient acquisition for plants and are basic determinants of soil nutrient status, crop growth and productivity. Although several factors such as soil characteristics, environmental parameters and crop management practices could influence the microbial community, the most important factor is the type of plant species present. It is known that a particular crop can have a strong impact on soil microorganisms (Curl and Truelove, 1986). The nature of microbial populations associated with perennial crops is expected to be nearly constant but the admittance of diversified crops including both annual and perennials can enhance the microbial activity which ulti-

mately helps in the growth of component crops. Coconut is one of the perennial crops that is agreeable to intensive cropping during most of its life period and offers greater possibilities for increasing agricultural production. Coconut palms can be grown under a diverse range of soil, *i.e*. from sandy to clayey soil (Menon and Pandalai, 1960). In the pure stand of coconut (7.5 m x 7.5 m), it can utilize only 25 per cent of the land area and the remaining 75 per cent is left unutilized (Kushwah *et al*., 1973). Coconut intensive cropping systems are primarily crop combinations that confront growing other compatible crops in the interspace available between the palms. The impact of growingcompatible crops under coconut-based cropping system on soil microbial biomassis an importantarena which had significant influence on the performance of main crop in addition to soil health improvement.

With the rising accentuation on low-input, environmentally friendly agricultural practices, there developed an interest in the management of soil microbiota to increase plant growth and for the improvement of soil microbiological foundations in the coconut based cropping system approach (Thomas and Prabhu, 2003). With this background, the present study was carried out.

Materials and Method

The experiment was carried out during 2021-2022 in a 50-year-old coconut plantation at Coconut Research Station, Balaramapuram, Thiruvananthapuram located at 8°22'52" North latitude and 77°1' 47" East longitude. Coconut was planted at a spacing of 7.5 m x 7.5 m. A warm humid climate was prevailed over the experimental site. The experiment was conducted in Randomized Block Design with eight crop combinations as the first factor and two nutrient levels for the floor crop as the second factor in three replications. The crop combinations were coconut + banana + turmeric (C_1), coconut + banana+ ginger (C_2), coconut + banana + cassava (C_3), coconut + banana + amorphophallus (C_4), coconut + papaya + turmeric (C_5), coconut + papaya+ ginger (C_6), coconut + papaya + cassava (C_7) and coconut + papaya + amorphophallus (C_8). The nutrient levels for the floor crop comprised of RDF for the floor crops as per the POP recommendations (N_1) and 75 per cent RDF for the floor crop (N_2). Each treatment consists of 4 palms per plot. Inter row space available between the four coconuts palmswas treated as one unit. Banana and papaya were planted 2 m away from the base of the palm as per the treatment. Three rows of banana/papaya were there in one unit. Banana (RDF-190:115:300 g plant^{-1}) and papaya (RDF- 40:40:80 g plant^{-1} at bimonthly interval) were fertilized as per POP recommendations (KAU, 2016) and floor crops *viz*., turmeric (RDF-30:30:60 kg ha^{-1}yr^{-1}), ginger (RDF-75:50:50 kg ha^{-1}yr^{-1}), cassava (RDF-100:50:50 kg ha^{-1}yr^{-1}) and amorphophallus (RDF-100:50:150 50 kg ha^{-1}) were fertilized as per the treatment. Floor crops were planted in the inter row spaces available between the three rows of banana or papaya. Turmeric and ginger were planted in beds, cassava in mounds and amorphophallus in pits. The intercrops were arranged in such a way that they get maximum incident light.

Collection of samples

Composite soil samples were collected from the interrow space to a depth of 0-25 cm at different locations both before and after the experiment.The population of bacteria, actinomycetes and fungi were determinedusing serial dilution plate technique (Johnson and Curl, 1972). To make several dilutions, the samples were serially diluted in sterile water blanks, and one ml aliquot was taken and spread on respective media taken in petri dishes. Such three replications were maintained for each group of microorganisms. Total counts of culturable bacteria on nutritional agar were counted after 24–48 hours of incubation at 28 °C, actinomycetes on Ken Knights were recorded after 5–7 days of incubation at 28 °C, and fungi on Martin's rose Bengal agar were counted after 2–4 days of incubation at 28 °C. The results were expressed in CFU (Colony Forming Unit) per gram of soil. Data were statistically analysed and the treatment means was compared at 5 per cent probability level. The bacterial population was 3.5 x10^6 CFU g^{-1} wet soil, fungal population was 0.7 x10^3 CFU g^{-1} wet soil, and actinomycetes population was 0.6 x10^4 CFU g^{-1} wet soil, for the soil samples analyzed before the start of the experiment.

Results and Discussion

Effect on bacteria population

The bacterial population was significantly superior for coconut + banana + turmeric (C_1) system (16.7x10^6 CFU g^{-1} wet soil), which was followed by

coconut + banana + ginger (C_2). The lowest bacterial population was contributed by in coconut + papaya + cassava system (C_7) (5.5 x10^6 CFU g^{-1} wet soil) and was statistically on par with coconut + papaya + amorphophallus system(C_8). The nutrient management practices for the floor crop resulted significant effect on the bacterial population. Application of 75 per cent RDF for the floor crop (N_2) recorded higher bacterial count (10.1 x10^6 CFU g^{-1} wet soil) when compared to the full dose of fertilizer application (Table 1).

The interaction effect had significant effect on bacterial population. Higher population was recorded in coconut + banana + turmeric system with 75 per cent RDF for the floor crop (c_1n_2) followed by coconut + banana + turmeric system with 100 per cent RDF for the floor crop (c_1n_1). The lowest population was observed in coconut + papaya + cassava system with 100 per cent RDF for the floor crop (c_7n_1) (Table 1).

An abundance in the population of bacteria was noticed when banana was intercropped with banana compared to papaya. Reddy *et al.* (2002) reported that there was an increase in the population of bacteria and P solubilizers under high density multispecies cropping system of coconut with banana.

Among the banana based intercropping system, the floor crop turmeric and ginger were found to have higher bacterial population under 75 per cent of the RDFwhile with tuber crops (cassava and amorphophallus) there was a reduction in bacterial population with 75 per cent RDF. The increase in the population of bacteria in the treatment c_1n_2 and c_2n_2 might be due to the increased availability of nutrientsresulted from the decomposition of green leaf mulch added on the beds of turmeric and ginger. Green leaves @ 15 t ha^{-1} were used for mulching as per the POP recommendations (KAU, 2016). The decomposed leaves act as a good source of organic matter along with the added fertilizers have contributed to increased nutrient status in the soil for the growth of bacteria in that particular cropping system. Farsanashamin and Anilkumar (2016) also opined that the bacterial population was the highest in treatments that are supplied with least dose of chemical fertilizers. The bacterium was found colonizing the root region of crops in coconut based high density multispecies cropping system and also under the mixed farming system. This was supported by Ghai and Thomas (1989) who had isolated *Azospirillum* from coconut based cropping system which contributed to the increased supply of N to the cropping system. Similar results were also reported by Nath and Deka (2010) that the population of bacteria was higher under coconut + pepper + turmeric cropping system followed by coconut + pepper +ginger and the lowest population in the control plot (coconut + pepper). Tuber crops *viz.*, cassava and amorphophallus recorded higher bacterial population in 100 per cent RDF.

According to Hridya and Byju (2014) the microbial biomass carbon was significantly highest (3.1g g^{-1} of wet soil) at 100 per cent RDF for cassava than 50 per cent RDF.

Effect on fungal population

Fungal population was also significantly influenced by crop combinations and floor crop nutrition. Contrary to the bacterial population, the fungal population was found to be higher in coconut + banana + ginger (C_2) (2.6 x10^3 CFU g^{-1} wet soil) followed by coconut + banana + turmeric (C_1). Coconut + papaya + cassava system (C_7) recorded the lowest fungal count (1.3 x 10^3 CFU g^{-1} wet soil). Among the nutrient management practices, the application of 75 per cent RDF for the floor crop (N_2) recorded higher fungal count (1.9 x10^3 CFU g^{-1} wet soil) when compared to the full dose of fertilizers to the floor crop (Table 1).

Among the interaction effect, higher fungal population was recorded in coconut + banana + ginger system with 75 per cent RDF for the floor crop (c_2n_2) followed by coconut + banana + turmeric system with 100 per cent RDF for the floor crop (c_1n_2). The lowest population was observed in coconut + papaya + cassava and coconut + papaya + amorphophallus system with 100 per cent RDF for the floor crop (Table 1).

The fungal population was comparatively less than that of the bacterial communityin the coconut based cropping system. According to Khonje *et al.* (1989) fertilizer application directly stimulates the growth of overall soil microbial populations by providing nutrients, but its effect on individual microbial communities varied differently. High density multispecies cropping systems of coconut provided higher bacterial population, while the fungal colonies were low (CPCRI, 2004). Among the fungal species, Arbuscular mycorrhizal fungi (AMF) were the predominant species reported in the soil samples collected from coconut based multistoreyed crop-

ping system. AMF helps for the uptake of immobile phosphate by the plants thus improving the overall growth and productivity (Smith and Read, 1997). In the present investigation, the cropping system including banana favoured higher fungal count than papaya. Coconut + banana system recorded significantly higher fungal colonies than other coconut-based cropping system in the midland laterites of Kerala. Mulching with green leaves on the beds of ginger and turmeric provided an additional organic source for the microbes and better performance was recorded with 75 per cent RDF for the floor crop in coconut + banana + ginger (c_2n_2). Microbial biomass and phosphatase activity were higher in 2/3rd RDF and under full dose of fertilizer in banana (CPCRI, 2001).

Effect on actinomycetes population

The actinomycetes population showed significant variation among the treatments. Coconut + banana + turmeric (C_1) recorded higher actinomycetes population (6.7 x10^4 CFU g^{-1} wet soil), which was

Table 1. Effect of crop combinations and floor crop nutrition on microbial population of in a coconut based cropping systems

Treatments	Population of bacteria (× 10^6CFUg^{-1} wet soil)	Population of fungi (x 10^3 CFU g^{-1} wet soil)	Population of actinomycetes (x 10^4 CFU g^{-1} wet soil)
Crop combinations (C)			
C_1 (C+B+T)	16.7	2.5	6.7
C_2 (C+B+G)	13.9	2.6	5.3
C_3 (C+B+Cassava)	9.8	1.8	4.4
C_4 (C+B+A)	9.0	1.7	3.7
C_5 (C+P+T)	8.1	1.6	3.0
C_6 (C+P+G)	7.5	1.5	2.5
C_7 (C+P+Cassava)	5.5	1.3	1.4
C_8 (C+P+A)	6.0	1.4	2.0
SEm(±)	0.18	0.03	0.09
CD (P=0.05)	0.362	0.095	0.268
Nutrient level for the floor crop (N)			
N_1 (RDF)	9.1	1.7	3.5
N_2 (75% RDF)	10.1	1.9	3.7
SEm (±)	0.09	0.02	0.05
CD (P=0.05)	0.181	0.047	0.134
Treatment combinations (C x N)			
c_1n_1	15.4	2.3	6.4
c_1n_2	18.0	2.7	7.0
c_2n_1	11.3	1.2	5.0
c_2n_2	16.5	3.1	5.5
c_3n_1	10.3	1.9	4.5
c_3n_2	9.3	1.7	4.1
c_4n_1	9.1	1.8	4.2
c_4n_2	8.9	1.6	3.1
c_5n_1	7.7	1.5	2.4
c_5n_2	8.6	1.6	3.7
c_6n_1	8.2	1.6	3.0
c_6n_2	6.9	1.5	2.1
c_7n_1	5.0	1.3	1.2
c_7n_2	6.0	1.4	1.6
c_8n_1	5.4	1.3	1.7
c_8n_2	6.7	1.4	2.3
SEm(±)	0.25	0.05	0.13
CD (p=0.05)	0.513	0.134	0.379

(C- coconut, B- banana, T-turmeric, G-ginger, A- amorphophallus)

followed by coconut + banana + ginger (C_2) and the lowest population was noticed in coconut + papaya + cassava system (C_7) (1.4 x10^4 CFU g^{-1} wet soil). 75 per cent RDF for the floor crop resulted in significantly higher actinomycetes population than the full dose of fertilizers for floor crop (Table 1).

Among the different crop combinations, higher population of actinomycetes (7.0 x 10^4 CFU g^{-1} wet soil) was recorded in coconut + banana + turmeric system with 75 per cent RDF for the floor crop (c_1n_2) followed by coconut + banana + turmeric system with 100 per cent RDF for the floor crop (c_1n_1). The lowest population was observed in coconut + papaya + cassava system with 100 per cent RDF for the floor crop (c_7n_1) (Table 1). Higher bacterial and fungal activities might have promoted higher actinomycetes population in coconut + banana + turmeric system with 75 per cent RDF for the turmeric (c_1n_2). Actinomycete plays an important role in the nutrient status of the soil through the decomposition of organic matter (Mullings and Parish, 1984). The added green leaf mulch on the beds of turmeric and ginger, farmyard manure and the decaying rootsof banana might have improved the organic matter content of the soil. According to Robinson (1987), the functional life span of primary roots of banana was from 4-6 months, secondary roots 8 weeks and tertiary roots were about 5 weeks. The decaying roots serve as a source of organic matter. Bhat *et al*. (2008) also suggested that banana maintained significantly higher actinomycetes counts followed by coffee and clovein coconut plantations.

In the present investigation, the variation in microbial population observed in different treatments might be due to the changes in soil physiochemical properties and the modification of the microclimate in the cropping system. Among the different crop combinations,the population of microorganisms was found to be the lowest in papaya basedcropping systems than under banana. According to Zhong *et al.* (2015), microbial biomass carbon was observed to be 18 per cent higher in banana-pineapple rotation and 8.6 percent higher in banana-papaya rotation compared to banana monoculture at 0–30 cm depth of the soil. Besides, organic carbon input from crop roots of banana, rhizosphere products and crop residues might havesignificant effect on soil microbial biomass and its activity, which in turn, affect the ability of soil to supply nutrients to plants (Bonde and Roswall, 1987). Application of 75 per cent RDF to the floor crop recorded higher microbial population compared to full dose of nutrients. The reduction in microbial population while increasing the inorganic source might be due to the toxicity of metal contaminants present in inorganic fertilizers (Marschner *et al.*, 2004). In addition to that, the basin management practices for coconut *viz*., application of FYM, chemical fertilizers and soil amendments coupledwith intercropping and application of 75 per cent RDF to the floor crop might have promoted highermicrobial activity in the soil.

Conclusion

Soil fertility largely depends on the microbial population of the soil. High density multispecies cropping in coconut provided congenial conditions for the growth and multiplication of microorganisms. The continuous addition of crop residues, root exudates and the modified microclimate exert a favourable condition for the multiplication of microorganisms. Higher number of roots per unit volume of soil could add more organic matter to the soil by the decay of dead roots. It could be concluded from the results that Nendran banana was the best intercrop for coconut compared to papaya and the best floor crop was turmeric/ginger. Coconut + Nendran banana + turmeric with 75 per cent recommended RDF for turmeric recorded the highest bacterial and actinomycetes population while coconut + ginger with 75 per cent recommended RDF for ginger recorded higher fungal population.

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