Eco. Env. & Cons. 28 (January Suppl. Issue) : 2022; pp. (S133-S137)

ISSN 0971–765X

http://doi.org/10.53550/EEC.2022.v28i01s.019

Effect of coconut based integrated cropping system on soil organic carbon and microbial populations in coastal Odisha condition

Gopa Mishra[1], S.C. Sahoo[1] A.K. Karna[1], S.K. Pattanayak[2] and H.P. Maheswarappa[3]

[1]Department of Fruit Science and Horticulture Technology, CA, OUAT, Bhubaneswar, Odisha, India
[2] Department of Soil Science and Agricultural Chemistry, CA, OUAT, Bhubaneswar, Odisha, India
[3]Project Coordinator (Palms), AICRP on Palms, ICAR- CPCRI, Kasaragod, India

(Received 13 July, 2021; Accepted 26 August, 2021)

ABSTRACT

Coconut (*Cocos nucifera* L) is an important high vale crop, however mainly grown by small and marginal farmers in the coastal Odisha condition. The poor productivity and profitability of coconut cultivation in the particular area owes to the poor nutritional management and sole cropping. The experiment was conducted by taking four intercrops (banana, pineapple, guava and colocasia) inside the coconut garden. Different combinations of nutrient sources were used and crop specific growth regulators were applied at specific growth stages. The study was conducted during 2016-17 and 2017-18 in order to assess the effects of cropping system, nutrient and growth management practices on the soil organic carbon (SOC) as well as the soil microbial population in two different soil layers in the system as well as insole cropping of coconut. Soil microbial populations act as an index of soil fertility due to their active role in nutrient mineralization in soil system. During both the years of investigation the soil organic carbon was found highest inside the cropping system. Both SOC and microbial population were found maximum in the cropping system soil managed with pure organic sources of nutrient.

Key words : *Sole cropping, Intercrops, Soil fertility and soil layers*

Introduction

Enhancement in the nutrient inputs, especially in the form of chemical fertilizers into agricultural system has became an essential practice. Chemical sources are regarded as major contributor in enhancing the yield and productivity of crop plants. Inorganic fertilizer application is preferred by the growers for its convenient use and quick response intensive agricultural systems, however impacting on the below ground microbial community. Microorganisms perform an important role in the nutrient cycling for sustaining the productivity of the soils. Microorganisms regulate the nutrient flow in the soil by assimilating nutrients and producing soil biomass (immobilization) and helps in mineralization of C, N, P and S (Wani and Lee, 1995;). In natural systems, these microbial nutrient transformations are key drivers of plant growth and development, and sometimes act as the rate-limiting step in ecosystem productivity (Schimel and Bennett, 2004). When the soil life gets disturbed, all biochemical transformation ceases endangering the sustainable production in agriculture Soils under monocultural systems, in general, contain significantly lower concentrations and qualities of soil organic matter, less soil structural stability, community diversity and soil organic carbon levels as compare to cropping system

(Debenport *et al.,* 2015; Reganold and Wachter, 2016; Wang *et al.,* 2017).

Coconut (*Cocos nucifera* L.) is an important high value perennial crop usually grown by small and marginal farmer in coastal Odisha. As per the research findings, only 23 % of land area and 30 % of active radiations are utilized by the coconut palm when it grows in recommended spacing (7.5m × 7.5m) (Maheswarappa *et al.,* 2001). The remaining unutilized land can be profitably utilized by the incorporating some intercrops which can fit into the climate and generally don't compete with the main crop. The addition of intercrops, annual or perennial will help the farmers to gain some additional income and it will add positive impact on the main crop yield and productivity.

Addition of organic sources of nutrients, biofertilizers can improve the biological properties of soil, improve the uptake of nutrient, by improving the mineralization and enhance the yield of the crop in a sustainable manner. Again the growth and yield of these crops can be improved further by application of specific growth regulator at specific period of growth stage and in definite concentration. Keeping the above fact in view the present investigation entitled "Effect of coconut based integrated cropping system on soil microbial population at different soil depths" was carried out during the cropping year 2016-17 and 2017-18.

Materials and Methods

The present experiment was conducted in the experimental farm, under the Department of Fruit Science & Horticulture Technology, College of Agriculture, OUAT, and Bhubaneswar during the period July 2016 to June 2018. The experimental area experiences a tropical humid climate. The sand, silt and clay percentage of the experimental soil was recorded prior to the experiment and were measured as 59.7%, 17% and 23.3 percent respectively. The soil pH was measured 5.5 whereas the organic carbon was 4.60g/kg.

The crop combination taken in the cropping system was coconut + banana+ pineapple + guava + taro. The coconut cv. Sakhigopal Local was grown as the principal crop at a spacing of 7.5×7.5 m. Banana cv. Poovan, pineapple cv. Queen, guava c.v. Arka Amulya and colocasia cv. Muktakeshi were taken as intercrops inside the coconut garden in organized manner. The integrated nutrition management (INM) practices were imposed along with plant growth regulators (PGRs). The treatments were finalized as

- T1: 75% of recommended NPK + 25 % N through organic recycling with vermicompost,
- T2: 75% of Recommended NPK+ 25% N through organic recycling with vermicompost + PGRs*;
- T3: 50 % of recommended NPK + 50 % N through organic recycling with vermicompost + in situ green manuring+ vermicompost wash + biofertilizers;
- T4:50 % of recommended NPK + 50 % N through organic recycling with vermicompost + in situ green manuring + vermicompost wash + biofertilizers + plant growth regulator*;
- T5: Fully organic (100 % N through organic recycling with vermicompost + in situ green manuring + vermicompost wash + CCP+ biofertilizers;
- T6:Fully organic (100 % organic recycling with vermicompost + in situ green manuring + vermicompost wash + CCP+ biofertilizers + PGRs*;
- T7: Sole cropping of coconut with 100% recommended doses of fertilizer.

The experiment was planned in randomized block design (RBD), with 7 treatments replicated 3 times. The analysis and interpretation of data were done by using the method of Panse and Sukhatame (1989).

In the present experiment, crop specific growth regulators were used. Freshly opened inflorescences in the palm were selected for PGR (plant growth regulator) application. 2-4-D @ 30ppm along with coconut water was applied to each inflorescence two weeks after the spathe splitting. In pineapple NAA @ 10 ppm was applied to the core of plant in the month of November, one month before the usual flowering time. For banana, 50 ppm GA_3 was applied at the time of bunch opening. NAA @ 50 ppm was applied on guava in the early stage of fruit setting.

The details of RDF (recommended doses of fertilizer) followed in the present experiment are described in Table 1. According to the doses of nutrient, each crop was managed. The NPK content of the organic sources was also estimated (Table 2) and accordingly the amount was calculated for application in different treatments. Two biofertilizers strains *Azotobacter* and *Azospirillum* were used. The different growth regulators were applied in the respective crops at the particular growth phases.

Table 1. Recommended doses of fertilizers applied in different crops in the cropping system

Crop	Recommended doses of fertilizers (g/plant/year)		
	N	P_2O_5	K_2O
Coconut	500	320	1200
Banana	250	125	300
Pineapple	12	4	12
Guava	500	320	300
Colocasia	80 (kg/ha)	25 (kg/ha)	100 (kg/ha)

The soil organic carbon was estimated by chromic acid wet digestion method explained by Walkley and Black (1934).

The enumeration of total bacteria, fungi and in the soil samples was carried out following the standard dilution plate count technique. Soil extract agar for bacteria Martin's Rose Bengal streptomycin sulphate agar for fungi was used. The petriplates were incubated at 30 °C for three to six days and population was counted and expressed as CFU g^{-1} of soil

Results and Discussion

Adoption of cropping system and different management practices has significant influence on soil organic carbon as well as on the bacterial and fungal population of soil.

The soil organic carbon was differed significantly among the treatments (Fig. 1). The highest amount of soil organic carbon (5.33gkg^{-1} soil) was recorded in the cropping system soil and lowest value (4.073gkg^{-1} soil) the monocropping. Again among all the nutrient and growth management practices followed inside the cropping system, the one maintained with pure organic sources of nutrient recorded highest soil organic carbon (SOC). The amount of SOC was found to decrease with increased doses of chemical fertilizers and also towards the subsurface layer of the soil.

The general bacterial population in the post-harvest soil (after 2 years of study) varied significantly between 2.56 x 10^6 CFUg^{-1} of soil and 8.81 x 10^6 CFUg^{-1} of soil (Table 3), lowest with inorganically (chemical) maintained soil and highest with the organic treatment. The beneficial fungal population was found less than bacterial population and ranged from 4.56 × 10^3 to 9.46 × 10^3 cfu ×10^3 g^{-1} soil in the surface layer after imposition of INM treatments. The lowest population of soil microbes was recorded under monocropping system managed inorganically (with or without use of growth regulator) and highest in organically fertilised soil under cropping system (Table 3 and Table 4).

High density cropping system and specially that under perennial crops likes coconut, creates a microclimate having slight deviation in the basic weather parameters like minimum and maximum temperature, soil moisture, relative humidity etc than outside. This type of microclimate affects the crop and the soil to a larger extent. The population of both fungi (4.57cfu × 10^3g^1 soil) and bacteria (2.56 cfu×10^6g^1 soil) was found minimum in the monocroped soil. The micro environment inside cropping system contributed significantly towards increase in population in the palm rhizosphere. Cropping systems, such as intercropping and no-tilling organic farming, increased microbial community diversity and soil organic carbon levels (Debenport *et al.*, 2015; Reganold and Wachter, 2016; Wang *et al.*, 2017). The current findings are in agreement with the findings of Maheswarappa *et al.* (2014) and Shinde *et al.* (2020).

Again the practices with organic integration like farm yard manure, vermicompost and green manuring helped in maintaining higher bacterial population significantly than non-integrated one. The microbial activity in the experimental soil indicated that sole use of inorganic nutrient sources didn't support the bacterial population (2.45 x 10^6 CFUg^{-1} soils). However under intercropping the bacterial population was found to be increased from 6.04 to 8.35 x 10^6 CFUg soil in surface soil after imposition of INM practices. Reduction of the proportion of in-

Table 2. The NPK content of the organic sources used in the system.

Organic sources	Nitrogen (%)		Phosphorous (%)		Potassium (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Vermicompost	1.4	1.6	0.24	0.23	0.36	0.36
Vermicompost wash	0.6	0.5	0.90	1.0	0.14	0.20
Cowpea (GM)	1.9	1.8	0.26	0.28	0.12	0.14
CCP	1.03	1.01	0.06	0.05	1.20	1.21

organic nutrients (75% or 50 %) influenced significantly the microbial population. It is reported that continuous application of farmyard manure (FYM) and green manure substantially improved the organic carbon under different soils and cropping systems (Wani and Lee, 1995). The use of biofertilizers might have also contributed to the increase in the microbial population of the soil.

In T_5 and T_6, the increase in soil carbon content might more congenial for the microbial growth. The complete organic nutrient sources in those particular practice helped maintaining higher microbial population. Incremental doses of inorganic nutrients and decremental doses of organics favoured decrease in fungal population in soil irrespective of soil depths in the cropping system model. The increase in soil organic matter that occurs in conservation tillage systems results in greater soil biological activity and soil biodiversity. Generally speaking, microbial biomass increases along with soil organic matter and makes up 1 to 4 percent of the total organic matter. Soil micro organisms form a complex food web, and soil organic matter act as base. Most soil microorganisms use the soil organic compound as

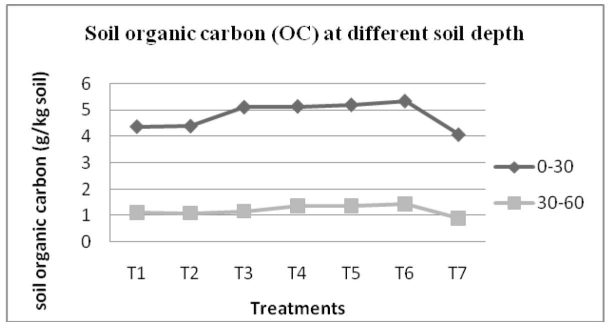

Fig. 1. Effect of coconut based integrated cropping system on soil organic content at different soil depths

carbon and energy sources. Some soil organisms feed directly on living roots, but most depend on dead plant matter. So in the current study, increase in the soil organic matter has a direct impact on the population growth of soil micro organisms. Studies have shown that avoidance in the use of synthetic fertilizers may lead to increased soil biodiversity and biological activity as compared to conventional forms of crop growth, monocropping of coconut with RDF (Boggs *et al.,* 2000).

The result indicated that, the top 0-30cm soil

Table 2. Effect of coconut based integrated cropping system on bacterial population (CFU×10^6g $^{-1}$soil) at different soil depth

Treatments	Bacterial population (0-30 cm)			Bacterial population (30-60 cm)		
	1st year	2nd year	pooled mean	1st year	2nd year	Pooled mean
T_1	6.04	6.10	6.07	3.35	3.42	3.39
T_2	6.06	6.15	6.11	3.24	3.40	3.32
T_3	7.67	7.87	7.77	3.39	3.48	3.43
T_4	7.55	7.84	7.70	3.36	3.52	3.44
T_5	8.05	9.29	8.67	3.83	3.90	3.87
T_6	8.35	9.27	8.81	3.84	3.91	3.88
T_7	2.45	2.67	2.56	2.14	2.36	2.25
C.D (0.05)	0.05	0.03	0.03	0.09	0.04	0.05

Table 3. Effect of coconut based integrated cropping system on fungal population (CFU ×10^3 g^{-1}soil) at different soil depth

Treatments	Fungal population (0-30 cm)			Fungal population (30-60 cm)		
	1st year	2nd year	Pooled mean	1st year	2nd year	Pooled mean
T_1	7.54	7.65	7.60	5.71	5.81	5.76
T_2	7.32	7.67	7.50	5.72	5.82	5.77
T_3	8.74	8.87	8.81	5.86	5.87	5.87
T_4	8.50	8.90	8.70	5.92	5.90	5.91
T_5	9.35	9.90	9.62	7.59	7.63	7.61
T_6	9.46	9.92	9.69	6.98	7.70	7.34
T_7	4.56	4.57	4.57	2.28	2.46	2.37
C.D (0.05)	**0.06**	**0.04**	**0.03**	**0.40**	**0.08**	**0.21**

found rich with microbes (both fungi and bacteria) than the subsurface soil layer due to higher organic carbon content in the surface soil. The subsurface soil had lower bacterial as well as fungal population than surface soil. Integrated manuring had same effect when imposed with or without the use of growth regulator. The fungal population decreased considerably in the sub surface layer irrespective of INM practices. The variation in the microbial population among the surface rhizospheric soil in the current study might be due to the different nutrient management practices followed which include sole inorganic, sole organic and integration of both in different combinations (Maheswarappa *et al*., 1999). Use of growth regulator had no significant effect on the soil microbial population in coconut rhizosphere.

References

Debenport, S. J., Assigbetse, K., Bayala, R., Chapuis-Lardy, L., Dick, R. P. and McSpadden Gardener, B. B. 2015. Association of shifting populations in the root zone microbiome of millet with enhanced crop productivity in the Sahel region (Africa). *Appl. Environ. Microbiol.* 81 : 2841–2851.

Maheswarappa, H.P., George, V.T., Gupta, A., Bhat, R. and Palaniswami, C. 2014. Productivity and nutrient status of coconut (*Cocos nucifera*) as influenced by integrated nutrient management with vermicomposted coconut leaves. *Indian Journal of Agronmony.* 59(3) : 455-459.

Maheswarappa, H.P., Hedge, M.R., Dhanpal, R., Sairam C.V. and Vidhan Singh, T. 2001. Impact of integrated mixed farming system in coconut *(Cocus nucifere)* garden on coconut yield and economic analysis. *Indian Journal of Agronomy*. 46 (1) : 56-63.

Maheswarappa, H.P., Nanjappa, H.V. and Hegde, M.R. 1999. Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden. *Annals of Agricultural Research.* 20(3) : 318–323.

Moore, J.M., Susanne, K. and Tabatabai, M.M. 2000. Soil microbial biomass carbon and nitrogen as affected by cropping systems. *Biol. Fertil. Soils*. 31 : 200–210

Panse, V. G. and Sukhatme, P. V. 1989. Statistical methods for agricultural workers. New Delhi: *Indian Council of Agricultural Research*. 5 : 258-260.

Reganold, J. P. and Wachter, J. M. 2016. Organic agriculture in the twenty-first century. *Nat. Plants*. 2 : 15221

Schimel, J. P. and Bennett, J. 2004. Nitrogen mineralization: challenges of a changing paradigm. *Ecology*. 85 : 591–602.

Shinde, V.V., Maheswarappa, H.P., Ghavale, S.L., Sumitha, S., Wankhede, S.M. and Haldankar, P.N. 2020. Productivity and carbon sequestration potential of coconut based cropping system as influenced by integrated nutrient management practices. *Journal of Plantation Crops*. 48(2) : 103-110.

Toyota, K. and Kuninaga, S. 2006. Comparison of soil microbial community between soils amended with or without farmyard manure. *Appl. Soil Ecol.* 33 : 39–48.

Walkley, A. and Black, I. A. 1934. Estimation of soil organic carbon by chromic acid and titration method. *Soil Sci*. 31 : 21-38.

Wang, Y., Li, C., Tu, C., Hoyt, G. D., DeForest, J. L. and Hu, S. 2017. Longterm no-tillage and organic input management enhanced the diversity and stability of soil microbial community. *Sci. Total Environ.* 609 : 341–347.

Wani, S.P. and Lee, K.K. 1995. Microorganisms as biological inputs for sustainable agriculture. In: Thampan, P.K. (Ed.), Organic Agriculture. Peekay Tree Crops Development Foundation, Cochin, India, pp. 39–76.