Nutrient Availability and Biochemical Properties in Soil as Influenced by Organic Farming of Papaya under Coorg Region of Karnataka

H. Ravishankar, G. Karunakaran and S. Hazarika
Central Horticultural Experiment Station, IIHR
Chettalli - 571 248, Kodagu, Karnataka
India

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Abstract

In the recent years, papaya cultivation in India has become more popular because of its high yield and nutritive qualities. There also have emerged niche markets for organically produced fruits especially in the urban areas. Keeping in view the emerging trend, a study was conducted at Central Horticultural Experiment Station (IIHR) during 2004-07 in order to organize modules for sustainable production of organic papaya var. 'Coorg Honey Dew' under Coorg region of Karnataka, India. In this study, the effects of seven different treatments viz., recommended dose of NPK fertilizers (250:250:500 g NPK plant^{-1} year^{-1} as check (T_1); FYM 20 kg/plant (T_2), urban compost 13.5 kg/plant (T_3), sun hemp 25 kg/plant (T_4), sun hemp 40 kg/plant + rock phosphate 300 g/plant (T_5), neem cake 4 kg + wood ash 2.5 kg/plant (T_6) and rural compost 35 kg/plant (T_7) applied to 'Coorg Honey Dew' papaya crop were studied on nutrient availability, microbial population and enzyme activities in sandy loam soil in a field experiment laid out in randomized block design with three replications. Soil analysis after three years of study indicated no significant effect of treatments on the status of available P and K and the pH of the soil. Organic matter content in soil was significantly influenced by different treatments with the highest values recorded under T_2 and T_3 treatments. Soils under different organic modules had significantly higher microbial population (bacteria, fungi and actinomycetes) and activities of urease, phosphatase, dehydrogenase and cellulases as compared to that under recommended dose of fertilizers (T_1). Significant positive association between organic matter status, microbial populations and enzyme activities in soil was recorded. Application of FYM 20 kg/plant (T_2) was the best organic module with regard to higher microbial populations and enzyme activities in soil.

INTRODUCTION

There is a paradigm shift in the consumers' preference to consume organically grown fruits and vegetables in the recent years. In this background, favourable effects of various components of organic farming over conventional farming or integrated nutrient management practices requires to be considered in a holistic perspective rather than looking at the short-term gains. Several studies have documented the effect of addition of organic manure to improve the soil microorganisms and enzyme activities (Krishnakumar et al., 2005; Hangarge et al., 2004; Prabhakar Reddy et al., 2007). The information on soil microbial and enzyme activities however in hilly, high rainfall regions having distinct ecosystem specificities is limited especially in papaya. With this background, effect of different sources of organic manures and inorganic nutrient applications on the soil microbial and enzyme activities under 'Coorg Honey Dew' papaya cropping in the Coorg region of Karnataka was assessed in this paper.

MATERIALS AND METHODS

The present study was initiated during 2004 with 'Coorg Honey Dew' papaya variety at Central Horticultural Experiment Station, (IIHR), Chettalli, Kodagu (Coorg), Karnataka. The experiment was laid out with six treatments of organic manure sources and one treatment representing recommended dose of fertilizers (Check) in randomized block design with three replications having sixteen plants per treatment. The details of the treatments are recommended dose of NPK fertilizers (250:250:500 g NPK plant^{-1} year^{-1} as check (T_1); FYM 20 kg/plant (T_2), urban compost 13.5 kg/plant (T_3), sun hemp 25 kg/plant (T_4), sun hemp 40 kg/plant + rock phosphate 300 g/plant (T_5), neem cake 4 kg + wood ash 2.5 kg/plant (T_6) and rural compost 35 kg/plant (T_7). The initial soil samples were collected prior to the commencement of the experiment and analyzed. The soil of experimental site was sandy clay loam with a pH range of 5.8-6.2, organic carbon 0.8-1.1%, E.C. 0.076 dS m^{-1}, available N 315 kg/ha, available P_2O_5 68 kg/ha and available K_2O 368 kg/ha. The organic manure treatments were applied at the time of planting, while inorganic fertilizers were applied in six split doses at an interval of two months. The different sources of organic manures were analyzed for nutrient status of N, P, K, Ca, Mg, Fe and Mn. The N concentration ranged from 1.36 to 3.20%, P from 0.386 to 1.45% and that of K from 0.40 to 1.90%. Calcium varied from 0.40 to 1.25%, Mg from 0.38 to 1.05%. The Fe concentration was high ranging from 1319 to 6130 ppm and that of Mn varied form 565 to 1930 ppm.

Three years after planting i.e. at the end of one crop cycle in 2007, soil samples collected from the respective organic manure treated plots were analyzed. The soil pH was determined with a pH meter having glass electrode using 1:2.5 soil:water ratio. The soil samples were dried, wet digested and analyzed for N by Kjeldahl method and phosphorus was estimated by vanado-molybdate method and K was estimated by flame photometer (Bhargava and Raghupathi, 2005). The different biological estimations were carried out by serial dilution technique for all the soil plate counts. Soil microorganisms were determined using standard methods of nutrient agar for bacteria and Ken Knight agar for actinomycetes (Allen, 1953) and Martin's Rose Bengal agar medium for fungi (Martin, 1950). Activities of urease (Tabatabai and Bremner, 1972), dehydrgenase (Casida et al., 1964), phosphatase (Tabatabai and Bremner, 1969) and cellulase (Panchloy and Rice, 1973) in soil were determined. The data were statistically analyzed using analysis of variance.

RESULTS AND DISCUSSION

Nutrient Availability

Organic carbon content of the soil increased significantly following addition of different organic modules (Table 1). The application of FYM (T_2), sun hemp 25 kg/plant (T_4) and rural compost (T_7) significantly influenced organic carbon content in soils over recommended dose of NPK fertilizers (T_1), however the different organic modules themselves were at par with each other. This implied that application of organic sources of nutrients contributed to the improvement of organic carbon in the soil. This is in congruence with the findings of Wang Yin-Po and Chao Chen Ching (1995).

Available N of the soil (Table 1) was maximum under neem cake and wood ash treatment (T_6) and T_2 and T_4. Urea [Co $(NH_2)_2$], a synthetic organic fertilizer is rapidly hydrolyzed to NH_4^+ by urease. Higher urease activity and microbial population as observed might have accelerated the mineralization rate. Our results are consistent with those reported by Sable et al. (2007) who found that application of neem cake and vermicompost significantly enhanced N, P and K uptake in tomato. N content of the soil however, did not vary appreciably due to treatments except with regard rural compost (T_7) and urban compost (T_3) which recorded lower values than even the recommended dose of NPK fertilizers (T_1) which may be due to the rate of mineralization. Mineralization of natural organic materials is mediated by heterotrophic bacteria and fungi. Organic N in natural organic materials is mostly of unstable forms readily mineralizable but also include stable forms that are resistant to mineralization e.g., lignin. Composting however stabilizes organic matter in the substrate. The lack of response to application of T_7 and T_3 in the present study is possibly explained by the factor of slow release of N form these sources (Kumar and Goh, 2003). Lower populations of bacteria and actinomycetes recorded in the present study (Table 2) in respect of T_7 and T_3 limiting access to substrates perhaps contributed to the slow rate of mineralization (Killham et al., 1993). It may be pertinent to mention here that it is difficult to predict the pattern and amount of available N released from organic sources during the growing season as it is primarily a biological decomposition governed by chemical composition, microbial dynamics, temperature and moisture availability (Kumar and Goh, 2003). The data on other soil chemical properties however remained unclear.

Microbial Population

In general, microbial population was significantly enhanced (Table 2) due to application of organic modules over check (T_1). Application of FYM (T_2) recorded higher fungi, bacteria and actinomycetes population than the recommended dose of NPK fertilizers (T_1). Krishnakumar et al. (2005) and Hangarge et al. (2004) reported similar results under organic farming. FYM application resulted in maximum microbial population which was at par with sun hemp 25 kg/plant (T_4), sun hemp + rock phosphate (T_5) but differed significantly with urban compost (T_3), neem cake + wood ash (T_6) and rural compost (T_7). The data clearly indicated the positive and favourable effects of organic manures application on microbial populations. This is attributed to the higher organic matter and available N contents of the soil arising from organic manures applications (Wang Yin Po and Chao Chen Ching, 1995). Further, the possibility of organic treatments leading to increased secondary and micronutrients in turn contributing to increased microbial populations can not be ruled out. These results are consistent with those reported by Neelima Garg et al. (2007) in guava by mulching with manures and in apple by Varga et al. (2000).

Soil Enzyme Activities

Enzyme activities were found higher in the organic manure treatments than in the (T_1) recommended dose of NPK fertilizer (Table 3). Among the organic modules, neem cake along with wood ash (T_6) showed significantly higher urease activity but, it was at par with FYM (T_2), sun hemp 25 kg/plant (T_4) and sunhemp + rock phosphate (T_5). The recommended dose of NPK fertilizers (T_1) showed significantly the least urease activity as compared to the organic modules.

The activities of dehydrogenase and phosphatase were significantly influenced by application of neem cake with wood ash (T_6) followed by FYM (T_2) and sunhemp + rock phosphate (T_5) which however were at par. Cellulase activity ranged from 0.92 to 1.98 mg of glucose released g^{-1} of soil 24 h^{-1}. Sunhemp + rock phosphate (T_5) treatment showed higher cellulase activity than the recommended dose of NPK fertilizer (T_1). Among the different organic modules also, significant differences were observed in respect of cellulase activity except in the case of T_4 (sun hemp 25 kg/plant) which may be due to high lignin content of the substrate (Kumar and Goh, 2003).

The high enzyme activities recorded with organic module applications could be attributed to higher microbial populations gaining access to readily mineralizable unstable forms. Variations in enzyme activities found among the organic modules applied might be due to the nature of organic materials used and status of readily mineralizable forms (Kumar and Goh, 2003). It is apparent that the soil enzyme activities are mainly dependent upon microbial status which in turn is governed by the organic matter status in the soil facilitated by addition of organic manures (Table 1). It was clear from their studies that, the use of organic manures stimulated the enzyme synthesis and assimilation, which finally boosted the soils capacity to cycle and supply the nutrients for the crop growth. The results of the present study indicated that the application of organic modules significantly influenced the soil microbial and enzyme activities which could improve soil health and attain sustainability in the long run for ‘Coorg Honey Dew’ papaya production.

Literature Cited

Allen, O.N. 1953. Experiments in soil bacteriology. Burgess Co., Minneapolis, Minn. p.69-70.

Bhargava, B.S. and Raghupathi, H.B. 2005. Analysis of plant material for macro and micronutrients. p.49-82. In: H.L.C. Tandon (ed.), Methods of analysis of soils, plants, waters and fertilizers. FDCO, New Delhi.

Casida, L.E., Klein, D.A. and Santaro, J. 1964. Soil dehydrogenase activity. Soil Sci. 98:371-76.

Hangarge, D.S., Raut, R.S., Hanwate, G.R., Gaikwad, G.K. and Dixit, R.S. 2004. Influence of coir pith compost and vermicompost application on the microbial population in vertisols. J. Soils and Crops 14(2):447-49.

Killham, K., Amato, A. and Ladd, J.N. 1993. Effect of substrate location in soil and soil pore-water regime on carbon turnover. Soil Biol. Biochem. 25:57-62.

Krishnakumar, S., Saravanan, A., Natarajan, S.K., Veerabadran, V. and Mani, S. 2005. Microbial population and enzymatic activity as influenced by organic farming. J. Agri. and Biological Sci. 1(1):85-88.

Kumar, K. and Goh, K.M. 2003. Nitrogen release from crop residues and organic amendments as affected by biochemical composition. Commun. Soil Sci. Plant Anal. 34:2441-2460.

Martin, J.P. 1950. Use of acid rose bengal and streptomycin in the plate method for estimating soil fungi. Soil Sci. 69:215-32.

Neelima Garg, Gorak Singh, Preeti Yadav, N. Goel and Soni, M.K. 2007. Effect of mulching on soil microbial population in Guava (*P. gujava*) orchard soil. Indian J. Agrl. Sci. 77(4):241-3.

Panchloy, K. and Rice, E.L. 1973. Soil enzymes in relation to old field succession: Amylase, cellulose, invertase, dehydrogenase and urease. Soil Sci. Soc. Amer. Proc. 37:47-9.

Prabhakar Reddy, T., Uma Devi, M., Chandrasekhar Rao, P. and Bhanumurthy, V.B. 2007. Effect of fly ash and farm yard manure on soil enzyme activities and yield of rice grown on an inceptisol. Crop Res. 34(1, 2 & 3):27-31.

Sable, C.R., Ghuge, T.D., Jadhav, S.B. and Gotre, A.K. 2007. Impact of organic sources on uptake, quality and availability of nutrients after harvest of tomato. J. Soils and Crops 17(2):284-87.

Tabatabai, M.A. and Bremner, J.M. 1969. Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. Soil Biol. and Biochem. 1:310-07.

Tabatabai, M.A. and Bremner, J.M. 1972. Assay of urease activity in soils. Soil Biol. and Biochem. 4:479-89.

Varga, C., Buban, T. and Piskolczi, M. 2004. Effect of organic mulching on the quantity of microorganisms in soil of apple plantation. J. of Fruits and Ornamental Plant Research 12:147-55.

Wang Yin-Po and Chao Chen Ching 1995. The effect of organic farming practices on the chemical, physical and biological properties of soils in Taiwan. p.33-39. In: Sustainable food production in the Asian and Pacific region. FETC book series, No. 46.

Willer, H. and Yussefi, M. 2004. The world of organic agriculture: Statistics and emerging trends. p.167. In: International Federation of Organic Agriculture Movements, Bonn, Germany.

Tables

Table 1. Nutrient status of the soil as influenced by different treatments in ‘Coorg Honey Dew’ papaya.

Treatment	Organic carbon (%)	Organic matter (%)	pH	Av. N (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_2O (kg ha^{-1})
T_1	1.01	1.32	5.50	373.00	92.00	426.80
T_2	1.22	2.43	5.79	375.00	94.67	365.33
T_3	1.14	2.37	5.65	343.67	87.67	390.80
T_4	1.27	2.07	5.65	371.00	98.33	373.37
T_5	1.08	2.11	5.58	362.33	103.67	393.50
T_6	1.15	2.15	5.98	394.67	100.33	421.83
T_7	1.21	1.96	5.51	315.33	96.33	374.13
S.Ed.	0.070	0.227	NS	10.842	NS	NS
CD (0.05)	0.154	0.493		23.623		

Table 2. Microbial population of the soil as influenced by different treatments in ‘Coorg Honey Dew’ papaya.

Treatment	Fungi (10^5 g^{-1})	Bacteria (10^6 g^{-1})	Actinomycetes (10^5 g^{-1})
T_1	4.34	2.26	1.51
T_2	8.75	6.23	3.52
T_3	7.05	4.30	2.97
T_4	8.25	5.17	3.21
T_5	8.02	5.10	3.53
T_6	7.15	4.43	2.42
T_7	6.97	4.11	2.15
S.Ed.	0.609	0.273	0.416
CD (0.05)	1.326	0.594	0.906

Table 3. Enzyme activity of the soil as influenced by different treatments in 'Coorg Honey Dew' papaya.

Treatment	Urease[a]	Dehydrogenase[b]	Phosphatase[c]	Cellulase[d]
T_1	0.557	3.63	5.00	0.92
T_2	0.770	6.43	9.20	1.65
T_3	0.633	4.57	6.70	1.39
T_4	0.740	5.17	8.33	1.87
T_5	0.780	6.10	9.07	1.98
T_6	0.813	6.57	9.63	1.73
T_7	0.677	5.13	7.87	1.56
S.Ed.	0.035	0.245	0.337	0.097
CD (0.05)	0.077	0.535	0.734	0.212

[a]mg NH_4^+ formed g^{-1} of soil h^{-1}
[b]g of TPF released g^{-1} of soil h^{-1}
[c]g of Nitrophenol released g^{-1} of soil h^{-1}
[d]mg of glucose released g^{-1} of soil h^{-1}