Journal of Root Crops, 2014, Vol. 40 No. 1, pp.
Indian Society for Root Crops
ISSN 0378-2409

Organic Management Impacts on Micro-Environment in Cassava

Alternative soil management practices like organic farming assume special significance in the context of global climate change for sustainable and safe food production, protection of environment and human health. Organic farming provides a clean environment by promoting soil quality and sequestering soil organic C. Cassava (*Manihot esculenta* Crantz) is an important tropical tuber crop that plays a significant role in the food and nutritional security. Cassava is the third largest source of food carbohydrates in the tropics, after rice and maize. It is grown for its starchy roots, which serves as a staple food and also a raw material for starch, sago and animal feed industries. It has the potential to produce maximum dry matter and has the ability to adapt to a wide range of climate and soil. The favourable impact of organic farming on growth, yield and soil properties of tuberous vegetables viz., elephant foot yam, tannia and yams has been documented (Suja et al., 2009; 2010; 2012a; 2012b; Suja, 2013; Suja and Sreekumar, 2013). However, there is limited information on the effect of alternative management practices like organic farming on the soil micro-climate (Montanaro et al., 2012). Hence the objective of this study was to investigate the effect of organic farming on the soil micro-environment changes and microbial count under cassava.

A field experiment was conducted during June-December 2012 at the Central Tuber Crops Research Institute (CTCRI) (8° 29'N, 76°57'E, 64 m altitude), Thiruvananthapuram, Kerala, India in an acid Ultisol, to compare the soil microbial biomass carbon, aggregate stability, soil CO_2 flux, soil temperature, soil moisture, photosynthetically active radiation (PAR) and soil microbial count under various production systems in cassava. Prior to the study, green manure cowpea was raised and incorporated in the land used for this study. Chemical inputs were not used for an year before taking up the present experiment. The soil of the experimental site was acidic in reaction (pH: 4.78), with low available N (159.94 kg ha^{-1}), high available P (163.30 kg ha^{-1}) and organic C (1.01 %) and medium K (162.33 kg ha^{-1}). The site experiences a typical humid tropical climate. The mean annual rainfall was 1850 mm, average maximum and minimum temperatures were 31.32°C and 25.75°C respectively and mean relative humidity was 75.60%.

The experiment was laid out in split plot design with three varieties, H-165 (industrial variety), Sree Vijaya and Vellayani Hraswa (domestic varieties) in main plots and five production systems, traditional, conventional, integrated and two types of organic in sub plots. Farmyard manure (FYM) @ 12.5 t ha^{-1} and ash @ 2 t ha^{-1} was applied in 'traditional plots'. In 'conventional plots' the nutrient management practices as per the package of practices recommendations (FYM @ 12.5 t ha^{-1} and NPK @100:50:100 kg ha^{-1}) was advocated. 'Integrated nutrient management' involving FYM @ 12.5 t ha^{-1} + NPK @ 50:25:100 kg ha^{-1}+ *Azospirillum* @ 3 kg ha^{-1} and phosphobacteria @ 3 kg ha^{-1} was another treatment. In 'organic farming plots', FYM @ 12.5 t ha^{-1}, *in situ* green manuring (fresh biomass @ 15-20 t ha^{-1}), crop residue incorporation (remaining plant parts of cassava after harvest of tubers which can contribute to dry biomass @ 3 t ha^{-1}) and ash @ 2 t ha^{-1} with/without biofertilizers (*Azospirillum* @ 3 kg ha^{-1}, phosphobacteria @ 3 kg ha^{-1} and K mobilizer @ 3 kg ha^{-1}) were applied to substitute chemical fertilizers. The gross plot size was 5.4 m x 5.4 m accommodating 36 gross plants and 16 net plants.

Aggregate stability was estimated by the wet sieving method using wet sieving apparatus. Microbial biomass C was determined by chloroform fumigation and extraction method (Vance et al., 1987). Soil CO_2 flux, soil temperature, soil moisture and PAR were measured at the grand growth period (4 MAP) of the crop using LI-8100 A Automated Soil CO_2 Flux System. Microbial plate count of bacteria, fungi and actinomycetes were determined at the time of harvest by standard procedures (Timonin, 1940). The analysis of variance of data was

Table 1. Soil micro-environment as influenced by production systems in cassava

Production systems	Microbial biomass C($\mu g\ g^{-1}$)	Aggregate stability (%)	Soil CO_2 flux ($\mu mol\ m^{-2}\ s^{-1}$)	Soil temperature (°C)	Soil moisture ($m^3\ m^{-3}$)	PAR ($\mu mol\ m^{-2}\ s^{-1}$)
Traditional	339.15	24.33	1.700	30.87	-0.055	685
Conventional	601.26	22.33	1.642	31.55	0.027	899
Integrated	449.65	24.19	1.503	38.29	-0.012	1135
Organic	860.36	27.91	1.433	31.19	0.012	791
Organic (Biofertilizers)	716.44	26.50	1.712	33.74	0.029	1066
CD (0.05)	349.75	NS	NS	3.555	NS	NS

done using SAS (2008) by applying analysis of variance technique (ANOVA) for split plot design.

Production systems significantly influenced the soil microbial biomass C (Table 1). Organic management had significantly higher microbial biomass C (860.36 $\mu g\ g^{-1}$) than integrated practice (449.65 $\mu g\ g^{-1}$). However, it was on par with that of conventional practice (601.26 $\mu g\ g^{-1}$). This is similar to the reports of Ramesh et al. (2010) who observed increase in microbial biomass C in organic manure amended soils due to increased availability of substrate-C that stimulated microbial growth and direct effect from microorganisms added through the various manures. Paikaray et al. (2011) also observed significantly higher values of soil microbial biomass in soils amended with green manures. In the present study, aggregate stability was not significantly influenced by the production systems. However it is worthy to mention that the aggregate stability, which is an important determinant of soil quality, was enhanced by 25% under organic management over conventional practice. Aggregate stability refers to the ability of soil aggregates to resist disruption when outside forces (usually associated with water) are applied. The stable soil aggregates helps to lower the strength of surface crust, making it friable and easy to work with and enhances water infiltration rates (Colla et al., 2000).

The soil CO_2 flux was found to be unaffected by production systems though a slightly higher value was observed under organic with biofertilizers when compared to conventional system, which may be due to the higher respiration rate as a result of enhanced microbial activity and root metabolism. Montanaro et al. (2012) reported 20% higher soil CO_2 emissions under alternative soil management practices involving organic amendments. The soil temperature was significantly higher under integrated practice, followed by the organic (with biofertilizers). The small rise in soil temperature may be due to the higher microbial activity consequent to the application of biofertilizers in these practices. The warming of the soil also probably enhanced the soil CO_2 efflux due to enhanced microbial activity. The soil moisture and PAR remained unaffected by the production systems, but were slightly promoted under organic management. The expanding foliage under organic management increases the canopy photosynthesis, which is a driver of soil respiration in addition to soil temperature and moisture (Tang et al., 2005).

The population of bacteria, fungi and actinomycetes were not significantly influenced by the production systems (Table 2). However, the counts were higher in all the production systems other than conventional system, where chemicals were not used or minimally used. Suja et al. (2012a; 2012b) and Suja and Sreekumar (2013) observed increased microbial population in cultivated organically managed soils under elephant foot yam and yams. The study supports the benefit of organic farming in improving the soil micro-environment and thereby soil quality.

Table 2. Microbial population of the soil (cfu g^{-1} soil) as influenced by production systems in cassava

Production systems	Bacteria (*10^6)	Fungi (*10^4)	Actinomycetes (*10^5)
Traditional	5.50	6.17	7.50
Conventional	2.50	4.83	6.00
Integrated	4.00	6.67	5.67
Organic	4.17	6.17	5.67
Organic (Biofertilizers)	3.33	6.17	6.67
CD (0.05)	NS	NS	NS

Acknowledgement

The authors gratefully acknowledge the Ministry of Environment and Forests, Govt. of India, New Delhi, India for the financial support and the Director, CTCRI, Thiruvananthapuram, Kerala, India, for providing facilities for carrying out the research work.

References

Colla, G., Mitchell, J.P., Joyce, B.A., Huyck, L.M., Wallender, W.W., Temple, S.R., Hsiao, T.C. and Poudel, D.D. 2000. Soil physical properties and tomato yield and quality in alternative cropping systems. *Agron. J.*, **92**: 924-932.

Montanaro, G., Dichio, B., Bati, C.B., Xiloyannis, C. 2012. Soil management affects carbon dynamics and yield in Mediterranean peach orchard. *Agric. Ecosyst. Environ.*, **161**: 46-54.

Paikaray, R.K., Garnayak, L.M. and Rath, B.S. 2011. Nutrient release dynamics in organic farming. In: *Recent Developments in Organic Farming*. Gulati, J.M.L. and Barik, T. (Eds.). Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India. pp. 375-385.

Ramesh, P., Panwar, N.R., Singh, A.B., Ramana, S., Yadav, S.K., Shrivastava, R. and Subha Rao, A. 2010. Status of organic farming in India. *Curr. Sci.*, **98**: 1190-1194.

SAS. 2008. SAS Users Guide. SAS Institute Inc. Cary, North Carolina, USA.

Suja, G. 2013. Comparison of tuber yield, nutritional quality and soil health under organic versus conventional production in tuberous vegetables. *Indian J. Agric. Sci.*, **83**(11):1153-1158.

Suja, G. and Sreekumar, J. 2014. Implications of organic management on yield, tuber quality and soil health in yams in the humid tropics. *Int. J. Plant Prod.*, **8**(3): 291-310.

Suja, G., Sreekumar, J., Susan John, K. and Sundaresan, S. 2012a. Organic production of tuberous vegetables: Agronomic, nutritional and economic benefits. *J. Root Crops*, **38**: 135-141.

Suja, G., Sundaresan, S., Susan John, K., Sreekumar, J. and Misra, R.S. 2012b. Higher yield, profit and soil quality from organic farming of elephant foot yam. *Agron. Sustain. Dev.*, **32**: 755-764 (doi 10. 1007/s 13593-011-0058-5).

Suja, G., Susan John, K., Ravindran, C. S., Prathapan, K. and Sundaresan, S. 2010. On farm validation of organic farming technology in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). *J. Root Crops*, **36**: 59-64.

Suja, G., Susan John, K. and Sundaresan, S. 2009. Potential of tannia (*Xanthosoma sagittifolium* L.) for organic production. *J. Root Crops*, **35**: 36-40.

Tang, J., Baldocchi, D., Xu, L. 2005. Tree photosynthesis modulates soil respiration on a diurnal time scale. *Global Change Biol.*, **11**(8): 1298-1304.

Timonin, M.I. 1940. The interaction of higher plants and soil microorganisms I. Microbial population of the rhizosphere of seedlings of certain cultivated plants. *Canadian J. Res.*, **181**: 307-317.

Vance, E.D., Brookes, P.C. and Jenkinson, D.S. 1987. An extraction method for measuring soil microbial biomass C. *Soil Biol. Biochem.*, **19**: 703-707.

Central Tuber Crops Research Institute,
Sreekariyam, Thiruvananthapuram 695 017, Kerala, India
Corresponding author: G. Suja, e-mail: sujagin@yahoo.com
Received: 20 March 2014; Accepted: 30 June 2014

Anish T. Anil
G. Suja
G. Byju and
S.S. Veena