Original Research

Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

Journal of Environmental Biology

JEB™ p-ISSN: 0254-8704
e-ISSN: 2394-0379
CODEN: JEBIDP

DOI : http://doi.org/10.22438/jeb/40/1/MRN887

Effect of organic and conventional farming practices on soil microbial population

Paper received: 05.04.2018 *Revised received*: 12.06.2018 *Re-revised received*: 16.06.2018 *Accepted*: 18.06.2018

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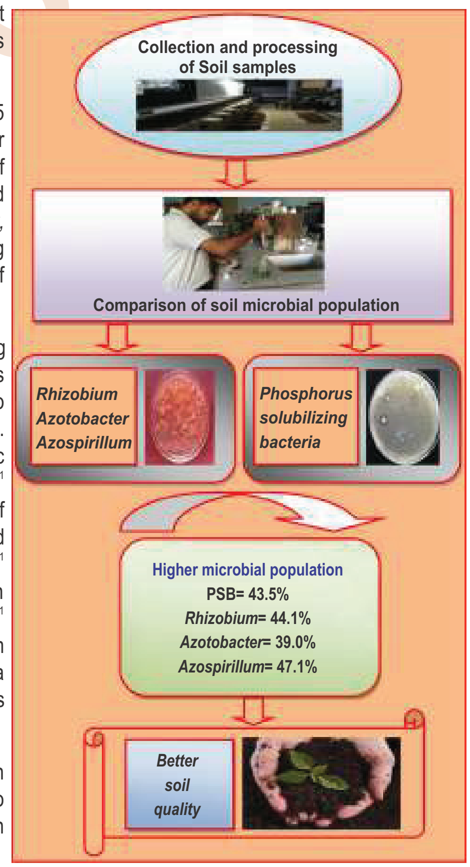
Abstract

Aim : Microbial community has an integral role in farming, but there is limited understanding of the complex response of microbial populations to organic and conventional farming systems. Therefore, the present study was carried out to study the effect of organic and conventional farming practices on soil microbial population in Haryana.

Methodology : Fifty surface soil samples (0-15 cm) were collected from organic and their adjoining conventional farms at 11 districts of Haryana. Soil samples were processed and analyzed for *Rhizobium, Azotobacter, Azospirillium* and phosphorous solubilizing bacterial (PSB) counts for the two types of farming systems.

Results : In comparison to conventional farming system, overall, population of PSB (which was 25.71×10^4 CFU g^{-1} soil) increased significantly to 36.91×10^4 CFU g^{-1} soil (an increase of 43.5%). Similarly, *Rhizobium* population in organic farming system increased from 29.26×10^4 CFU g^{-1} soil to 42.14×10^4 CFU g^{-1} soil (an increase of 44.1%). The population of *Azotobacter* increased significantly from 15.83×10^4 to 22.01×10^4 CFU g^{-1} soil (39.0%), while *Azospirillium* population increased from 13.66×10^4 to 20.10×10^4 CFU g^{-1} with an increase of 47.1%. Thus, it is clear from the results that organic nutrient sources showed a stimulating influence on the microbial populations of organic farming.

Interpretation : Higher microbial population recorded in organic farming in comparison to conventional farming leads to better soil health and increased productivity.



Key words: *Azospirillium, Azotobacter,* Conventional farming system, Organic nutrients, *Rhizobium*

How to cite: Sheoran H.S., V.K. Phogat and R. Dahiya : Effect of organic and conventional farming practices on soil microbial population. *J. Environ. Biol.*, **40**, 125-129 (2019).

Introduction

Growing concerns about the environmental, economic and social effects of chemical-dependent conventional farming system have led farming community, scientists, and researchers to seek alternative systems that make agriculture more sustainable while providing safe and quality food for ever growing population. Among alternative farming systems, organic farming is more popular now-a-days, however, both organic and conventional farming employ their own methods and practices, and have their own challenges and implications, particularly with respect to the impending global food crisis coupled with climate change (Uddin et al., 2016). It has, already been witnessed that traditional methods of food production are failing to provide a solution to the expected food shortage (Iqbal, 2010). At the same time, current degradation rates of the natural resources have serious implications for their management and need for increased food production (Warner *et al.,* 2010). These issues are compelling to think about some improved farming systems/practices, which may feed the increasing population while maintaining the ecosystems. Organic farming is a holistic approach to food production which is sustainable in terms of its long term effects on ecosystem by excluding or limiting the use of fertilizers, pesticides and genetically modified organisms (Pimentel *et al.,* 2005).

In recent years, multiple studies comparing conventional and organic agriculture have reported differences in soil properties, higher microbial activity and diversity in organically managed soils, or distinct microbial profiles between the two systems (Wu *et al.,* 2008). Effect of different farm management practices (conventional and organic) on the soil biochemical and microbial populations have been studied and researchers have reported that microbial population (bacteria, fungi, actinomycetes, *Beijerinckia, Azotobacter, Rhizobium, Bacillus* and phosphobacteria) were higher in soils from organic farming than sustainable and conventional farms (Carine *et al.,* 2009; Sudhakaran *et al.,* 2013; Uddin *et al.,* 2016) Bobulska *et al.* (2015) reported large differences between the organic and conventional sites in terms of microbiological properties, which are sensitive soil indicators of changes occurred under different farming systems.

The study confirmed the positive influence and higher microbial activity indices of eco-friendly farming practices (36% higher enzymatic activity, 65% higher soil respiration content, 60% higher soil microbial biomass carbon content) compared to conventional farming system. Moeskops *et al.* (2010) compared the effect of organic and conventional farming practices on soil microbial dynamics in West Java, Indonesia and concluded that based on the amounts of marker fatty acids, all microbial groups considered (actinomycetes, total bacteria and fungi) were significantly higher in organically managed soil than in soil from conventional farms. Though various studies with regard to biological properties of soils have been investigated and compared, the conventional with organic farming practices, but noticeable changes in soil properties, can occur only after longterm organic farming. The real picture of overall sustainability in organic farming, however, continues to face many challenges. For instance, there is disagreement over the organic farming in fulfilling the requirement of food production and difficult to evaluate its sustainability. Such concerns require greater understanding of the long-term effects of organic farming system and its feasibility as an alternative to the conventional practices, for sustainable use of natural resources. Keeping in view the above concerns, the present study was planned with the objective to determine the effect of organic and conventional farming practices on soil microbial population in Haryana.

Materials and Methods

Study area : Organic farms under different cropping systems, vegetables and horticultural crops and their adjoining conventional farms were identified at eleven districts of Haryana, namely Sirsa, Fatehabad, Hisar, Jind, Kaithal, Karnal, Kurukshetra, Ambala, Panchkula, Yamunanagar and Panipat and their soil properties were studied. A total of 50 soil samples at 0-15 cm depth, in triplicates, were collected from two types of farming systems and analysed for viable counts of *Rhizobium, Azotobacter, Azospirillium* and phosphorous solubilizing bacteria (PSB) in soils under organic and conventional farming practices.

Processing of soil samples and methods of analysis : Soil samples collected were refrigerated at 4°C for analysis of the microbiological properties. The serial dilution plating method (Lindow *et al.,* 1978) was used for enumeration of viable counts for *Rhizobium, Azotobacter, Azospirillium* and PSB. Plates with serial dilution plating were incubated for 5 days and the number of colonies on different dilution media plates were recorded and population per gram soil was enumerated.

Statistical analysis : The significance of treatment effects was analyzed using two factorial RBD analysis using OP Stat, CCS HAU Hisar, software.

Results and Discussion

Viable counts of phosphorous solubilizing bacteria, *Rhizobium, Azotobacter* and *Azospirillium*: The organic farming practices significantly influenced the microbial populations in soil and the phosphorous solubilizing bacteria (PSB), *Rhizobium, Azotobacter* and *Azospirillium* populations were higher in the organic farming as compared to conventional farm system (Table 1, 2). Under conventional farming system, the PSB showed variations from 8.0×10^4 to 52.4×10^4, *Rhizobium* population varied from 10.8×10^4 to 57.3×10^4 CFU g^{-1} soil at different locations (Table 1). The corresponding range of population of PSB and *Rhizobium* under organic farming ranged from 13.1×10^4 to 67.8×10^4 CFU g^{-1} and 16.3×10^4 to 86.3×10^4 CFU g^{-1} soil, respectively. Similarly, under conventional farming system, *Azotobacter* population ranged from 6.7×10^4 to 32.3×10^4

Table 1: Effect of organic and conventional farming practices on Phosphorus solubilizing bacteria and *Rhizobium* populations in soil at different locations

Location (L)	District	Village	Phosphorus solubilizing bacteria (CFU g^{-1} soil × 10^4)			*Rhizobium* (CFU g^{-1} soil × 10^4)		
			Conventional	Organic	Mean	Conventional	Organic	Mean
L_1	Panchkula	Billa	11.3	15.2	**13.2**	14.4	21.3	**17.9**
L_2	Sirsa	Mamad Khera	8.0	13.1	**10.6**	10.8	16.3	**13.5**
L_3	Panipat	Kurad	18.9	21.0	**20.0**	21.5	30.3	**25.9**
L_4	Panchkula	Tabar	17.0	26.8	**21.9**	18.4	25.6	**22.0**
L_5	Sirsa	Kharian	19.8	29.4	**24.6**	24.6	29.6	**27.1**
L_6	Fatehabad	Zandli Kalan	16.6	24.5	**20.5**	18.7	26.3	**22.5**
L_7	Fatehabad	Hasinga	14.6	20.3	**17.4**	19.5	24.6	**22.1**
L_8	Hisar	Shahpur	21.4	28.7	**25.1**	22.8	29.5	**26.1**
L_9	Hisar	Biyana Khera	24.0	34.5	**29.2**	25.8	32.5	**29.1**
L_{10}	Panipat	Bahuapur	17.2	25.3	**21.3**	29.3	36.5	**32.9**
L_{11}	Jind	Ikkas	19.7	28.4	**24.0**	24.3	38.8	**31.5**
L_{12}	Yamunanagar	Amadalpur	22.5	32.0	**27.3**	20.5	34.5	**27.5**
L_{13}	Jind	Balerkha	20.8	33.1	**26.9**	29.3	47.8	**38.5**
L_{14}	Kaithal	Kailram	26.3	36.8	**31.5**	32.5	40.1	**36.3**
L_{15}	Kurukshetra	Mangoli Jattan	28.0	38.8	**33.4**	34.3	41.8	**38.0**
L_{16}	Kaithal	Hajwana	25.8	42.1	**33.9**	31.8	46.3	**39.0**
L_{17}	Hisar	Ramayan Daderi	20.7	39.3	**30.0**	28.6	44.2	**36.4**
L_{18}	Panipat	Sink	33.1	45.8	**39.5**	34.6	44.6	**39.6**
L_{19}	Yamunanagar	Kandroli	39.6	49.5	**44.6**	37.8	52.5	**45.1**
L_{20}	Fatehabad	Gilla Khera	28.8	41.3	**35.1**	35.7	49.3	**42.5**
L_{21}	Sirsa	Shahpur Begu	32.4	51.2	**41.8**	42.3	53.8	**48.0**
L_{22}	Kaithal	Sikanderpur kheri	37.6	55.4	**46.5**	23.8	57.8	**40.8**
L_{23}	Jind	Palwan	49.2	64.2	**56.7**	57.3	86.3	**71.8**
L_{24}	Karnal	Kachhwa	37.2	58.2	**47.7**	47.2	69.6	**58.4**
L_{25}	Ambala	Sherpur Sulkhani	52.4	67.8	**60.1**	46.3	73.8	**60.0**
Mean			**25.7**	**36.9**		**29.3**	**42.1**	
CD at 5%			Location (L) = 3.4, Farming system (F) = 0.9, L x F = 4.8			Location (L)= 4.2, Farming system (F) = 1.2, L x F = 5.9		

CFU g^{-1} soil, while those of *Azospirillium* varied between 3.6×10^4 to 35.1×10^4 CFU g^{-1} soil at different locations (Table 2). The corresponding range of *Azotobactor* and *Azospirillium* population under organic farming was 10.0×10^4 to 36.7×10^4 CFU g^{-1} soil and 5.3×10^4 to 40.0×10^4 CFU g^{-1} soil, respectively. Overall, organic farming resulted in a significant increase in population of PSB from 25.7×10^4 to 36.9×104; *Rhizobium* from 29.3×10^4 to 42.1×10^4, *Azotobactor* from 15.8×10^4 to 22.0 ×10^4 and *Azospirillium* from 13.7×10^4 to 20.1×10^4 CFU g^{-1} soil. The percent increase in population of PSB, *Rhizobium, Azotobacter* and *Azospirillium* was observed to be 43.5, 44.1, 39.0 and 47.1%, respectively, upon shifting from conventional to organic farming system.

It was observed that the increase in population of PSB under organic farming was significant in all the different textured soils, while in case of *Rhizobium, Azotobacter* and *Azospirillium,* it was non-significant in sandy soils as compared to conventional system. As far as cropping system is concerned, it is difficult to compare the microbial population of two types of farming systems as the soils of the study area are under organic farming practices for 2 to 17 years. Organic nutrient sources showed a stimulating influence on the microbial population such as phosphate-solubilizing bacteria (PSB) and other nitrogen fixing microbes like *Rhizobium, Azotobacter* and *Azospirillium,* as seen by the increase in their viable counts in soil.

These soil microbial population were significantly greater with organics as compared to conventional system of farming. Microbial population (PSB, *Rhizobium, Azotobacter* and *Azospirillium*) was found to be higher upon shifting from conventional to organic farming system (Schjonning *et al.,* 2002; Crecchioa *et al.,* 2004; Melero, 2006; Araujo, 2009; Amaral *et al.,* 2011) due to the permanent input of organic residues with high C/N ratio. Further, it may be attributed to the fact that in the organic system large carbon inputs in the form of organic

Table 2 : Effect of organic and conventional farming practices on *Azotobacter* and *Azospirillium* populations in soil at different locations

Location (L)	District	Village	*Azotobacter* (CFU g^{-1} soil × 10^4)			*Azospirillium* (CFU g^{-1} soil × 10^4)		
	Conventional	Organic	Mean	Conventional	Organic	Mean		
L_1	Panchkula	Billa	11.1	13.1	**12.1**	5.7	6.9	**6.3**
L_2	Sirsa	Mamad Khera	6.7	10.0	**8.4**	3.6	5.3	**4.4**
L_3	Panipat	Kurad	9.0	12.3	**10.7**	6.3	10.2	**8.3**
L_4	Panchkula	Tabar	13.1	16.3	**14.7**	9.2	15.9	**12.6**
L_5	Sirsa	Kharian	9.2	13.6	**11.4**	10.8	12.6	**11.7**
L_6	Fatehabad	Zandli Kalan	13.3	16.2	**14.7**	6.6	8.6	**7.6**
L_7	Fatehabad	Hasinga	11.1	18.2	**14.7**	5.9	7.2	**6.6**
L_8	Hisar	Shahpur	9.8	14.0	**11.9**	8.2	14.8	**11.5**
L_9	Hisar	Biyana Khera	14.2	21.2	**17.7**	9.4	17.4	**13.4**
L_{10}	Panipat	Bahuapur	12.6	19.9	**16.2**	7.1	15.6	**11.3**
L_{11}	Jind	Ikkas	9.8	17.6	**13.7**	9.5	16.1	**12.8**
L_{12}	Yamunanagar	Amadalpur	15.4	19.3	**17.3**	11.5	18.9	**15.2**
L_{13}	Jind	Balerkha	13.8	22.4	**18.1**	13.1	21.6	**17.4**
L_{14}	Kaithal	Kailram	14.9	24.5	**19.7**	12.1	19.5	**15.8**
L_{15}	Kurukshetra	Mangoli Jattan	19.2	23.1	**21.1**	13.1	22.8	**18.0**
L_{16}	Kaithal	Hajwana	16.3	21.4	**18.9**	15.5	21.2	**18.4**
L_{17}	Hisar	Ramayan Daderi	19.2	25.0	**22.1**	14.7	18.8	**16.7**
L_{18}	Panipat	Sink	16.7	26.8	**21.7**	21.4	28.0	**24.7**
L_{19}	Yamunanagar	Kandroli	19.0	26.5	**22.7**	16.5	24.3	**20.4**
L_{20}	Fatehabad	Gilla Khera	21.3	27.7	**24.5**	19.0	25.5	**22.3**
L_{21}	Sirsa	Shahpur Begu	18.4	28.0	**23.2**	16.4	29.2	**22.8**
L_{22}	Kaithal	Sikanderpur kheri	22.3	30.7	**26.5**	23.1	32.2	**27.7**
L_{23}	Jind	Palwan	32.3	36.7	**34.5**	35.1	40.0	**37.6**
L_{24}	Karnal	Kachhwa	24.0	34.2	**29.1**	25.6	34.3	**30.0**
L_{25}	Ambala	Sherpur Sulkhani	22.8	31.7	**27.2**	21.8	35.6	**28.7**
Mean			**15.8**	**22.0**		**13.7**	**20.1**	
CD at 5%			Location (L) = 1.6, Farming system (F) = 0.5, L x F = 2.3			Location (L) = 2.1, Farming system (F) = 0.6, L x F = 2.9		

amendment is applied that supply available carbon. Additionally, the increase in population of PSB, *Rhizobium, Azotobacter* and *Azospirillium* in organic farming practices is, probably, also due to the large substrate (carbon) available for microbial growth contained in the organic amendments (Jadhav *et al*., 2016). Therefore, overall, microbial population was higher in the organically managed soils due to high carbon input in the soil.

The better level of biological quality of soils under organic farming system was due to regular addition of organic materials in the surface layer (Dhaliwal *et al.,* 2009). Increased availability of substrates (C and N) required for microbial population buildup could be the probable reason for this increase (Bunemann *et al.,* 2006; Sudhakaran *et al.,* 2013). Uddin *et al.* (2016) studied the impact of organic and conventional practices on the physicochemical properties, behavior and persistence of plant beneficial microorganisms, including *Rhizobium, Azotobacter,* phosphate solubilizing bacteria etc., and reported that population of beneficial soil microbes and health properties including pH, nitrogen content, organic matter, phosphorus, K, Ca and S increased significantly in the compost-amended soils compared to the conventional practices. Similar trend was also followed in the case of viable counts of *Rhizobium, Azotobacter, Azospirillium* and PSB. Higher microbial population in clay loam soils may be due to higher organic matter content, water retention characteristics and nutrient availability (Grayston *et al.,* 2004) along with the higher carbon content in these soils.

From the research findings, it can be concluded that adopting of organic farming showed a stimulating influence on the N-fixing microbial populations of *Rhizobium, Azotobacter* and *Azospirillium* along with phosphate solubilizing bacteria. Overall, soil microbial populations were higher in soils under organic farming, indicating higher microbial activity under organic farming.

Conversion of land from conventional to organic farming found to have better soil quality in terms of higher microbial populations of soils which is essential for enhancing soil productivity and other functions of soil in the given ecosystem. In the present agriculture scenario, organic farming may be adopted or promoted as an alternative to the conventional farming practices for sustainable use of natural resources, particularly, with respect to the impending global food safety coupled with climate change.

Acknowledgment

The authors are thankful to CCS Haryana Agricultural University, Hisar for providing the financial assistance and other facilities to conduct this research work.

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