Eco. Env. & Cons. 29 (April Suppl. Issue) : 2023; pp. (S302-S305)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i02s.049

Comparative analysis of soil toxicity and microbial content in organic vs conventional farming fields

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Received 2 June, 2022; Accepted 31 August, 2022)

ABSTRACT

After attaining self sufficiency in food grain production with the help of advancement in agriculture, in recent time awareness has increased regarding ill-effects of this advancement. Organic farming is seen as a practice to get rid of chemicals that evolved during green revoluion in the name of fertilizers and pesticides. A comparative analysis of parameters like heavy metal, phenol and microbial content of soil samples collected for conventional farming from farmer field of Kharad village and for organic farming from Chaudhary Charan Singh Haryana Agricultural University (CCSHAU) research farm in Hisar district Haryana, India was done. The results proved that Organic farming substantially reduces toxicity of heavy metals and keep the concentration of heavy metals in check. Also overall population of microbes is very well sustained in organic farming not only in numbers term but also in diversity. So it can be suggested from the study that organic farming practice is a sustainable way to preserve healthy soil environment.

Key words : *Conventional farming, Organic farming, Heavy metals, Phenols, Microbial count.*

Introduction

Food grains production has multiplied manifolds wheat production at nine times and rice production at three times of what they were in the 1960s. It was only due to a new strategy of agricultural development called as "green revolution" (Evenson and Gollin, 2003). This strategy involved the use of a high yielding variety of seeds, advanced irrigation techniques and use of chemical fertilizers. But this achievement also has brought many problems related to environment such as land, water and resource degradation: these problems are mainly due to wide usage of chemical fertilizers and pesticides. By their behavior, pesticides are potentially toxic to other organisms, this includes humans, and need to be used safely and disposed of properly (World Health Organization, 1990).

Pesticides are a compound mix of chemicals that are used to check or kill pests, including insects, rodents, fungi and unwanted plants (weeds). Currently India ranks twelfth in the world in pesticides consumption and second in Asia (Sam *et al*., 2008). According to an estimate out of million tons of pesticides that are applied annually only 0.1% gets to the target pests (Carriger *et al.,* 2006). According to agricultural statistics 5% of India's total pesticides is consumed in Haryana having 3% of India's total cropped area and 2% of India's total population also Haryana is top among northern states in fertilizer consumption (Agricultural stats of India, 2011).

Pesticides lead to contamination of ecosystem to heavy metals even blood serum of farmers in exposure to pesticides found to be contaminated (Cruzerio *et al*., 2015). These are very harmful to humans even in small quantities as there is no excre-

tory mechanism for them in the human body, Lead effects the central nervous system, kidneys and reproductive system; Cadmium accumulates in the kidneys and liver producing severe disease in the organs (Ghosh *et al*., 2012).

Soil fatigue due to exploitation for high productivity is cause of conern, leading to decline in the response of crops to applied chemical fertilizers (Biswas and Sharma, 2008). Chemical based agricultural practices have been involved in deteriorating soil health by adverse effects such as nutrient losses, reducing soil fertility, and declining microbial lives in soil (Tilman *et al*., 2001). Also, the use of higher dosage of chemical fertilizers containing single ingredient such as nitrogen (N), phosphorus (P), and potassium (K) and lesser use of organic fertilizers have lead to decrease of secondary and micronutrients particularly zinc (Zn) and iron (Fe) (Chhonkar, 2008).

Materials and Methods

Study Area: Our study area lies in Hisar in the North Western part of Haryana having 83.30% of its total area of 3983 sq km as net sown area. It is one of the best wheat producing areas of Haryana:- other major crops include Cotton, Rice, Mustard and Bajra. Our sampling area that is fields of CCSHAU, Hisar for Organic farming and village Kharad's farmers field for conventional farming which is located 6 km from national highway 9 at coordinates 29°8′32"N and 75°54′7"E. Source of irrigation are canal water and ground water, mean annual rainfall is 300mm only. Rice-Wheat cropping system is prevalent here and at the time of sampling wheat crop was there at 30 DAS stage. Soil type of the area is sandy to sandy loam.

Soil sample collection: Soil was collected using Auger from three different locations in the field after removing top 1" of the soil to remove the vegetation. For microbial analysis fresh soil was kept at 4 degree Celsius and for heavy metals estimation soil was dried in oven and passed through 2 mm sieve.

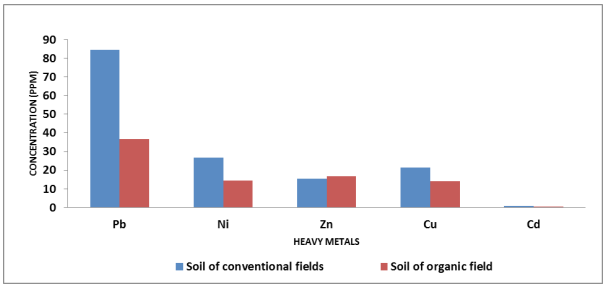
Heavy Metals estimation: It was done using Nitric acid digestion method (Sastre *et al*., 2002). To determine the Heavy metals content of soil Nitric acid was used as a digestor and soil sample in Nitric acid was heated on a hot plate till boiling point. The solution was filtered through Whatman filter paper No.42. Filtrate was analyzed through Atomic spectrophotometer at different wavelengths according to metals need to be detected.

Culturable Soil Bacterial Analysis: The analysis was designed with Luria-Bertini (LB) media (Ueno *et al*., 2006). To determine the effect of pesticides and fertilizers on soil bacterial population cultivation of soil bacteria was done on Luria-Bertini (LB) medium pH 7.4, containing (g/L); Tryptone 10g, NaCl 5g, Agar 16g and Yeast extract 5g. Soil bacterial population was determined by serial dilution technique. Serial dilution ranging from 10^0 to 10^{-7} were prepared for all soil samples. 20 µl of each soil solution were spread on the plate using glass spreader. Plates were incubated at 30 °C for 48 hours and colony forming units were counted and morphotype of bacteria's was analyzed.

Results

Heavy metals content of the samples were in trace amounts only. However in the case of Pb content, it is highest in the conventional farming soil. Ni content is al higher in conventional field. Except for Zn other heavy metals are in higher quantities in sample then the organic field soil, Zn in both the practices is similar.

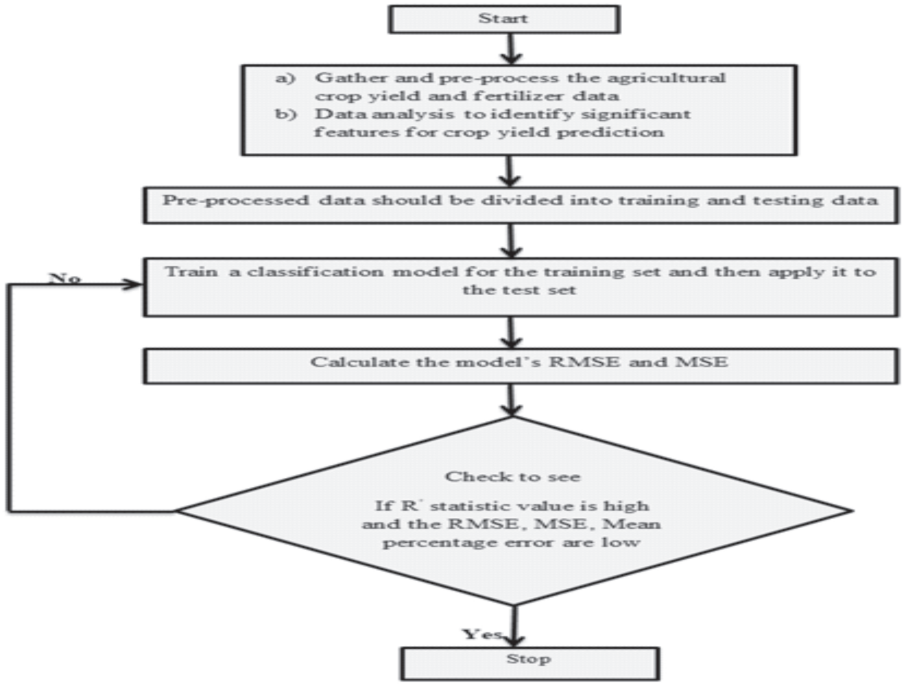
Colony forming units of bacteria are higher in the organic field soil as compared to the conventional field soil, it is highest in the 10^0 soil dilution and decrease with increase in dilution factor, however this



Graph. Heavy metals and their concentration in samples

Table 1. Heavy metals content of soil determined using Atomic Spectrophotometer

	Pb	Ni	Cd	Zn	Cu
Soil of conventional fields	84.36	26.57	0.92	15.47	21.27
Soil of organic field	36.59	14.56	0.58	16.69	14.01



Soil sample from conventional farming fields

Fig. 2. LB plates showing C.F.U spread with different soil serial dilutions ranging 10^0 10^{-3}

decrease is gradual in the case of organic field soil as compared to conventional field soil where C.F.U decreased to one-third in the first dilution only. Unpaired T test results shows the two tailed P value as 0.0024, so these differences are very statistically significant.

Table 2. Colony Forming Units (CFU) count at different soil serial dilutions

Dilution	Soil of conventional fields	Soil of organic field
10^0	169 ± 20	380 ± 32
10^{-1}	54 ± 7	175 ± 20
10^{-2}	19 ± 7	79 ± 15
10^{-3}	1 ± 1	14 ± 5
10^{-4}	0	2 ± 2

Bacterial types were few in the case of conventional farming soil sample whereas there is diversity in the organic field soil, even at the dilution of 10^{-3} there were four morphotypes oh bacterial species whereas it was only of one type in the case of conventional field soil at the same dilution. However at the 10^0 concentration the morphotypes were comparable between sample and organic field soil with four and five morphotypes respectively.

Discussion

Heavy metals estimation of sample and organic field soil revealed, although both the samples had heavy metals within the desirable levels except for the Zinc which is in very low quantities then the requirement

Table 3. Morphotypes of soil bacteria

Dilution	Soil of conventional fields	Soil of organic field
10^0	Cocci, ellipsoid, branched rod, curved rod	Cocci, branched filament, branched rod, ellipsoid, curved rod
10^{-1}	Ellipsoid, cocci	Cocci, branched filament, ellipsoid
10^{-2}	cocci	Cocci, branched rod, ellipsoid
10^{-3}	cocci	curved rod, ellipsoid, cocci, branched rod
10^{-4}	Nil	cocci

of crops such as Rice. Recently (Glodowska *et al*., 2017) it was observed that a significant reduction in the amounts of heavy metals in soil due to the addition of organic fertilizers. Concentration of lead although in safe limits but is high as 84.36 ppm in conventional farming field besides other heavy metals are also even though in safer limits but are lower in organic farming field.

Number and types of bacteria on LB agar plates of the organic field soil were found to be much higher than that of the conventional field soil as the use of pesticides and fertilizer in the fields have led to the destruction of micro fauna. At 10^0 to 10^{-2} dilutions conventional field has even less than half of colony forming units (CFU) as compared to conventional farming. Also, the bacteria type were much fewer in the conventional field soil whereas in the case of organic field soil even at the dilution of 10^{-3} there are four types of bacteria are available in comparison to conventional field soil in which there is only one type that is cocci. High CFU counts in organic farming soil may be due to high nutrients and organic carbon and absence of high concentration of heavy metals as there is no pesticide use that inhibits the growth of microbes. Soil rich in the bacterial population is expected to more active in solubilization of insoluble nutrients that lead to the nutrient richness of the soil.

Conclusion

Organic farming substantially reduce toxicity of heavy metals and keep the concentration of heavy metals check whereas in conventional farming due to use of chemicals heavy metal concentration increase with time. Overall population of microbes is very well sustained in organic farming not only in numbers term but also in diversity whereas in conventional agriculture the useful microbe's numbers in soil are in trace amounts which also increase dependency of plants on more chemical inputs to fulfill the need of nutrients. So, it can be concluded that organic farming not only maintains good microbial biomass, it also reduces toxicity in soil by keeping in check the heavy metals.

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