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Impact of Selected Organic Ameliorates on Pesticide Degradation

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Abstract Pesticides are the chemical substances that are used to eliminate weeds - herbicide, insects - insecticides and protect the plants from diseases - fungicides for better crop production. To meet the present and future food demand, use of pesticides in larger quantity is the only way to reduce losses in agricultural production as pesticide application is cheap and cost effective. This results in contamination of agricultural lands, surface and ground water, even food and food products contaminated with pesticide residue. Hence to assess the pesticide residue in the soil using different organic ameliorates, an incubation experiment was carried out to investigate the efficiency of the organic amendments. The inculbation experiment was laid out in a Completely Randomized Block Design with eight treatments viz., jeevamruth, vermicompost, enriched vermicompost, FYM, enriched FYM, waste decomposer, ganajeevamruth with a control replicated thrice. The results revealed that the enriched vermicompost was able to potentially improved the dehydrogenase activity (44 micro gram/dry wt of soil) and better pesticide degradation followed by enriched FYM, jeevamruth, FYM, vermicompost, waste decomposer and ganjeevamruth. Soil treated with enriched vermicompost resulted in degradation of the following pesticides viz., methyl parathion, alachlor, malathion and lindane. According to previous researches, dehydrogenase activity was found to be the deciding factor for the presence of pesticide residues in soil.

Keywords FYM, Vermicompost, Waste composer, Jeevamruth, Pesticide degradation.

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Introduction

Conventional farming played an important role in improving the food and fiber productivity to meet the human demands which has largely depended on the high rate of synthetic fertilizers and pesticide application. Currently, more than 500 different pesticide formulations are being used in agriculture, consequently the use of pesticide greatly increased their adverse effects on environment and human health. Each year about 2 million tonnes of pesticides are consumed

globally of which USA and Europe alone consume 24 and 45% respectively. India consumes 3% total world consumption of pesticides in that 67% of pesticides are used for agriculture and horticulture. Consumption of insecticides (76%) are higher, followed by herbicides (10%) and fungicides (13%). The highest consumption rates of pesticides in India include monocrotophos, endosulfan, phorate, chlorpyriphos, methyl parathion, quinalphos and phosphamidon (Ishwar Chandra Yadav et al. 2015). Mode of action of pesticides are not species specific so there is an increased risk of pesticide exposure to human and other living organisms. Pesticide contamination hazards from short term (Eye and skin irritation, dizziness, headache and nausea) to chronic diseases (cancer, asthma and diabetes). Shah (2016), Sarfraz Hussain et al. (2009) reported that application of pesticides potentially reduced the microbial population in the native soil, as the suitable soil condition for microbial survival got disturbed and altered. Pesticide residues reach human through food and drinking water by leaching, seepage and field run off that result in contamination of water bodies with pesticides and other synthetic chemicals. Two conditions responsible for the persistence of pesticide in the environment, one is that the neighboring microorganisms incapable of biodegrading the toxicity of the pesticide compounds and another factor is nature of the pesticide compounds that are highly resistant to degradation and recalcitrant (Frazar 2000). Bioremediation is one of the emerging novel technology to clean up the contaminated sites, this technology enhances the microorganisms in the native soil which improves the *in-situ* degradation of pesticide compounds (Chen et al. 2015). Amending organic inputs increases the microbial population of soil by providing more carbon source and keeps the soil biologically active (Ravindra Singh and Sharma 2014). Organic food production ensures the food security and sustainable agricultural production (Equle 2019, Qaim 2018). Biostimulation, a novel technology results in enhancing the soil microbial load and soil enzyme activity which fastens the degradation process in soils (Sima 2011). Enzyme catalyzed degradation pesticides potentially removes the toxic compounds from the contaminated sites. Soil dehydrogenase activity directly indicates the pesticide contamination, as dehydrogenase activity is higher in low dose of pesticide applied soils (Ndakidemi 2008).

Materials and Methods

Incubation experiment

The experimental soil was collected from pesticide contaminated field at a depth of 15 cm from the earmarked experiment plot area, located at Karunya nagar, Thondamuthur block, Coimbatore. Soil samples collected were brought to the laboratory, shade dried, sieved at 4 mm size. The incubation experiment was carried out in the Quality Control Laboratory of the Department of Sustainable Organic Agriculture. TNAU, Coimbatore. About 500g of processed soil were weight into 1 kg capacity polythene incubation boxes. The experiment was carried out in a CRD with eight treatments including control replicated thrice. The details of treatment as follows : T_1 - Jeevamruth (200 l/ha), T_2 - Vermicompost (5 tonn / ha), T_3 - Enriched vermicompost (1 tonn /ha), T_4 - FYM (15 tonn /ha), T_5 - Enriched FYM (1 tonn /ha), T_6 - Waste decomposer : A culture developed by the National Center of Organic Farming (NCOF), Gaziabad, UP (100 l/ha) and T_7 - Ganajeeuamruth (200 kg/ha), T_8 – Control. The treatments were imposed according to the weight of soil taken for the incubation experiment based on the recommendation given by TNAU respectively.

Soil sampling and analysis

Soil samples were drawn on 0^{th} day and 60^{th} day, initial soil physico chemical characters were analyzed. Smples were analyzed for the dehydrogenase activity using Spectrometry (NP Navnage 2018) and the multi-residue analysis was carried out using GC-MS (Perkin Elmer Model : Clarus 600) at the DRDO. Research Center, Bharathiyar University, Coimbatore. Microbial enumeration was done to evaluate the number of Colony Forming Units (CFU) by bacteria, fungi and actinomycetes (SA Waksman 1922). Multi residue pesticide analysis sample extraction protocol given by Jose Vera (2013).

Results and Discussion

Potential risk of soil contaminated with persistent organic pollutants (pesticides) to human health and natural ecosystem having high attention nowadays

Table 1. Initial characteristics of experimental soil.

pH	7.47
EC (dSm^{-1})	0.1
N (kg/ha)	218
P (kg/ha)	18
K (kg/ha)	185
Organic carbon (%)	0.49
Dehydrogenase activity (micro gram/dry wt of soil)	21

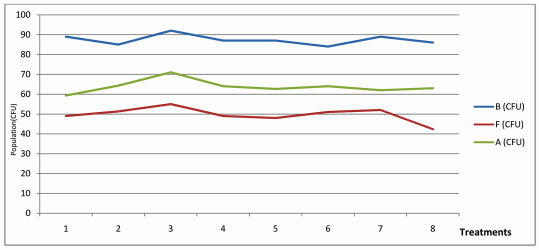

Fig. 1. Microbial population 60 days after incubation.

many methods have been developed to minimize the risks. Bioremediation is a novel technology proven prompt technique that increases the soil organic content and soil fertility based decontamination (Chen et al. 2015). Microorganisms that are present in the soils can remove pesticides from the environment and degradation of persistent chemical substances by enzymatic reactions have been found high bioremediation potential (Baba Uqab and Ruqeya 2016). Pesticide degradation in a highly contaminated soil using organic ameliorates was attempted.

Physico-chemical characters

Initial soil physico-chemical characters are given in Table 1. The results showed that a minimum level of organic matter (>0.1%) is essential to ensure the presence of an active autochthonous microbial population which can degrade pesticides (Durgesh Kumar Jaiswal 2016). The effect of organic amendment on pH, EC, organic carbon, nutrient status and biological properties of the experimental soil is furnished in Table 2. There is significant difference in pH among the treatments. The Electrical Conductivity upon all treatments got increased, application of the organic amendment that resulted in mineralization process hence available nutrients (N,P, K) in the soil also increased, which are vital for the growth of the crop. In the present investigation, application of enriched vermicompost (T_3) @ 1 tonn/ha recorded the maximum N, P, K status of 250 kg/ha, 23.5 kg/ha and 190 kg/ha respectively followed by T_5 (enriched FYM @ 1 tonn/ha) which recorded the N, P, K status 244 kg/ha, 20.8 kg/ha, 186 kg/ha respectively. The lowest N, P, K status of 230 kg/ha, 19.4 kg/ha, 180 kg/ha was recorded in T_6 (Waste decomposer @100 l/ha). Similar trend was noticed in organic carbon content too. Vermicompost is naturally rich in nutrients, enzymes and organic acids hence enriched vermicompost is high in nutrient content and other qualities. Vermicompost can be enriched by adding azospirillum,

Table 2. Change in physico-chemical characteristics of experimental soil due to organic ameliorants. T_1 - Jeevamruth (200 l/ha), T_2 - Vermicompost (5 tonn/ha), T_3 - Enriched vermicompost (1 tonn/ha), T_4 - FYM (15 tonn/ha), T_5 - Enriched FYM (1 tonn/ha), T_6 - Waste decomposer (100 l/ha) and T_7 - Ganajeevamruth (200 kg/ha), T_8 - Control.

Treatments	pH	EC (dS/m)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Organic carbon (%)	Dehydrogenase activity (micro gram/dry wt of soil)
T_1	7.35	0.43	237	19.8	184	0.48	40.1
T_2	7.39	0.32	243	20.7	181	0.36	19.3
T_3	7.31	0.33	250	23.5	190	0.53	44.1
T_4	7.35	0.33	242	20.2	182	0.43	36.2
T_5	7.37	0.45	244	20.8	186	0.49	41.1
T_6	7.32	0.31	230	19.4	180	0.34	14.1
T_7	7.32	0.35	241	20.7	183	0.37	14.7
T_8	7.23	0.26	228	19.1	178	0.39	26.1
Mean	7.33	0.35	242.31	20.42	185.45	0.42	26.9
SEd	0.0209	0.0109	2.4071	1.4807	1.6085	0.0199	0.0199
CD (0.05)	0.0443	0.0232	5.1029	3.1390	3.4099	0.0423	0.0423

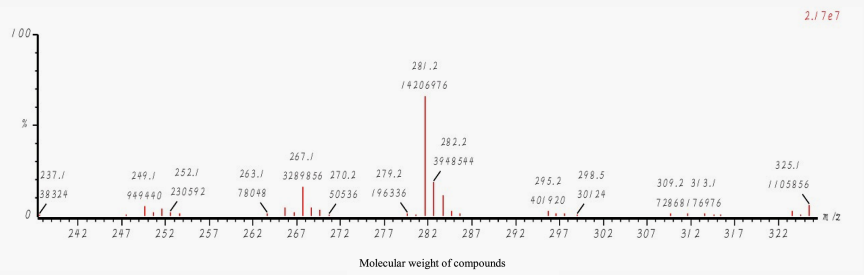

Fig. 2. Pesticide residue in initial experimental soil.

phosphobacteria and rock phosphate each 200 g/100 kg of compost. Presence of organic acids and microbial cultures enhanced the availability of nutrients in soil, as organic acids play a major role in solubilizing phosphorus. Organic carbon in soil also increased due to application of enriched vermicompost.

Dehydrogenase activity

After the application of organic ameliorants, the soil dehydrogenase activity had increased significantly. Application of enriched vermicompost (T_3) increased the dehydrogenase activity in the soil upto 44.10 micro gram/dry wt of soil compared to other treatments. Dehydrogenase activity in the soil directly indicates the large number of active microorganisms in the soil. From Figure 1, it is evident that microbial load in soil increased after the application of organic input. Enzyme catalyzed bioremediation is highly potential because of shorter reaction times (G Eibes et al. 2015), several intracellular and extracellular enzymes that are capable of hydrolyzing many pesticide compounds some of them adsorbed and made immobilized by the effect of the pesticides might be reduced (Shardendu Kumar and Ashraf 2018). On comparing the dehydrogenase activity, enzyme activity is higher in organic ameliorates added soil than the control. Hence, higher dehydrogenase activity indicates that the soil is low in pesticide contamination (Ndakidemi 2008).

Pesticide degradation

Using GC-MS (Perkin Elmer, Clarus 600) residue analysis was carried out. The results showed that pesticide compounds such as methyl parathion (269.8 m/z), alachlor (269.8, 270 m/z), malathion (330.4 m/z), lindane (290 m/z) had been reduced from detectable level to below detectable level in soil treated with enriched vermicompost (T_3) at 60th day, while Pendimethalin (281 m/z) reduced from 60% to 10% (Figs. 2 and 3). Degradation of pesticide compounds in the soil ecosystem is carried out by microbial activity through enzymatic degradation, being a reliable method for decontamination. Enzymes are also involved in the degradation of pesticide compounds, both in the target organism, through intrinsic detoxification mechanisms and evolved metabolic resistance, and in the wider environment, via biodegradation by soil and water microorganisms. Fungal

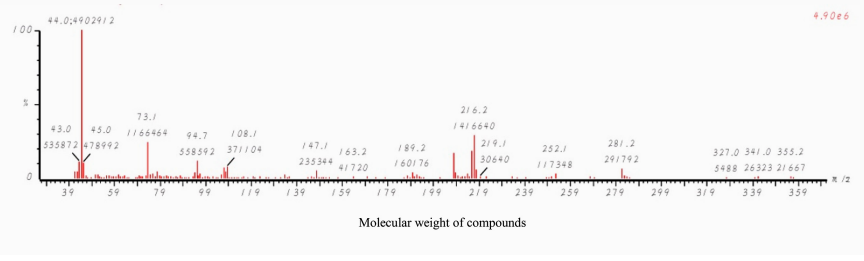

Fig. 3. Pesticide residue 60 days after treatment.

enzymes especially, oxidoreductases, laccase and peroxidases have prominent application in removal of polyaromatic hydrocarbons (PAHs) contaminants (Kavita Rani 2014).

Conclusion

An incubation experiment conducted using pesticide contaminated soil using different organic ameliorates showed that enriched vermicompost application at 1 tonn/ha higher dehydrogenase activity indicating the maximum degradation of the multi residue pesticide of the contaminated soil over a period of 60 days incubation.

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