Impact of Vermicomposting in Agricultural Waste Management vis-à-vis Soil Health Care

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Abstract

Accumulation and putrefaction of various wastes may cause several adverse effects on environment and living organisms including human health. Preparation of vermicompost (organic manure) from various organic wastes will save our environment as a whole; simultaneously organic wastes can also be managed properly. With this background for saving our environment from use of chemical fertilizers through proper management of agricultural wastes, an experiment was carried out in the farmer's field at village Bhabanipur, Block Haringhata, District Nadia, West Bengal, India) during the year 2013 – 2014 with two crops (Rice-*kharif*/ rainy season and Lentil-*rabi*/winter season). It has been found that the application of vermicompost showed better result in comparison to chemical fertilizers in terms of soil physical and chemical properties as well as productivity of soil.

Key words: Chemical fertilizer, Organic waste, Soil health, Vermincompost

Introduction

The green revolution in mid 1960s, steered by research based new technological development involving new materials, methods and ways of organizing farm inputs like water, fertilizer, chemical etc. and the government policy, transformed agriculture dramatically. As a result, the output exhibited manifold increase in production and productivity. Despite this magnificent progress during the last few decades the grim side of the story cannot be ignored. Much of this success is attributed to the intensive use of chemical fertilizers, pesticides, irrigation water etc. Chemicals are accumulated gradually inside the soil and deteriorate its health. Our country occupies dismally a low position with respect to yield levels in comparison to many other countries. Planners, agricultural scientists and agricultural economists are badly worried about the slow growth rate of agricultural production in recent years. At the dawn of new millennium, evidences are overwhelming that an agricultural transformation is needed to meet the global challenges of feeding ever escalating human population, conserving the environment and reducing poverty. On the other hand land is shrinking resource for crop production; to gain sustainable food and nutritional security, it is necessary to increase the yield of crops per unit area per unit time through judicious application of agro-techniques without hampering the ecological balance. Recent studies, however, excessive use of fertilizers is the need for additional land outside the public and environmental health of the reported adverse affects. Excessive use of chemical fertilizers in agricultural land causes large number of environmental problems. When it is applied inadequate, rates of productivity and quality are caused significant losses (Savci, 2012). In this background, use of organic manure such as vermicompost may improve quality of agricultural products. Vermicomposting is the process of producing compost through the action of earth-worm. It is an eco-biotechnological process that transforms energy-rich and complex organic substances into stabilized humus-like product vermicompost. Preparation of vermicompost is an efficient as well as easily adoptable technique of compost preparation. This composting system can not only decompose a huge amount of organic wastes but also help to maintain higher nutrient status in composted materials (Bajsa *et al*., 2004; Lazcano and Domínguez, 2011; Hema and Rajkumar, 2012). Vermicomposting technology using earthworms (as versatile natural bioreactors for effective recycling of organic wastes to the soil) is an environmentally acceptable means of converting waste into nutritious composts for crop production (Edward *et al*., 1985; Yadav *et al*., 2010). Moreover, by processing of garbage, this technology converts the problem into a resource and provides good manure which can be used to enhance quality of the soil (Azarmi *et al*., 2008). Yadav and Garg (2011) explored the use of vermicomposting technology in food industry waste management. In view of the above, an approach has been made in the proposed experiment to partially or entirely supplement the chemical fertilizer with the use of vermicompost for improving the productivity of crops. The objectives of the present study are: Preparation of vermicompost from available agricultural waste (organic) through vermiculture biotechnology. Studies on yield of rice (*kharif*/rainy season) and lentil (*rabi*/winter season) under different nutritional management. Studies on physical and chemical properties of soil after application of vermicompost or / and chemical fertilizer.

Materials and Methods

Study area

Field experiments were conducted at the farmer's field at village Bhabanipur, Block Haringhata, District Nadia, West Bengal, India. The experimental soil is loam in texture containing 33.7% sand, 40% silt and 26.3% clay. The study was undertaken during the year 2013– 2014.

Preparation, collection and analysis of used vermicomposts

Vermicompost was prepared by Heap method (Basak *et al*., 2011). This compost was collected from Animesh Mondal, a progressive farmer and owner of the vermicomposting plant of Village and Post Madanpur, Dist. Nadia, West Bengal, India. The chemical parameters viz. organic C, total N, P and K of used vermicompost were determined. The Organic carbon was determined by Walkley and Black's rapid titration method (Jackson, 1973). Total nitrogen was estimated by Modified macro Kjeldahl method (Jackson, 1973). Total phosphorus was determined by Olsen's method (Jackson, 1973) and Total potash was determined by the Flame photometer method (Jackson, 1973).

About crops

Two crops namely rice and lentil (Rice – *kharif*/rainy season and Lentil – *rabi*/winter season) were selected and sown. Their varieties were IET-4094 (Khitish) and B-77 (Asha) respectively. The experiment was laid out in Randomized Block Design with 4 treatments (T_0- without fertilizer or manure, T_1-100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic through mixed organic manure + 50% chemical through fertilizer) replicated 3 times. Yield and yield components were recorded and analyzed during two successive cropping years (2008-'09 and 2009-'10).

Soil analysis

After collection (twice- before crop establishment and after harvesting of crops), the soil samples were prepared for analyses in the laboratory. For preparation of soil samples different procedures were involved such as- Drying, Grinding, Mixing, Partitioning, Sieving etc. Different physical and chemical properties were analysed by the using different methods. Bulk density was determined by the method of Blake and Hartge (1986). Total porosity was estimated from the bulk density and particle density. Mechanical analysis of soil samples was determined following the Boyoucous hydrometer method (Gee and Bauder, 1986).

The water holding capacity (WHC) of the soil was measured with the help of Keen- Rackzowski box as described by Baruah and Barthakur (1997). Saturated hydraulic conductivity was calculated by Dracy's equation. Organic carbon was determined by Walkley and Black's rapid titration method (Jackson, 1973). Available nitrogen was estimated by Kjeldahl method (Jackson, 1973). Available phosphorus was determined by Olsen's method (Jackson, 1973) and Available potassium was estimated by the Flame photometer method (Jackson, 1973).

Results and Discussion

From Table 1 it is clear that the applied vermicompost was composed of 11.7% organic carbon, 1.26% total nitrogen, 2.01% total phosphorus and 0.77% total potash. Similar results were observed by Purohit (2006) and Karmakar *et al*. (2009). They opined that depending upon the nature of substrate, on an average the vermicompost contained 10.12-11.98% organic carbon, 1.09-2.75% total nitrogen, 2-2.45% total phosphorus and 0.78-1.39% total potash.

Table 1. Chemical composition of applied vermicompost

Composts	Organic C (%)	Total N (%)	Total P_2O_5 (%)	Total K_2O (%)
Vermicompost	11.7	1.26	2.01	0.77

Table 2 shows that different yield components (number of panicles m^{-2} and percent filled grain) and yield (grain yield and straw yield) of rice crop grown during the year 2013 and 2014, differed significantly with different nutritional management treatments. In case of both year the maximum number of panicles m^{-2} was recorded with the crop receiving 100% organic through vermicompost (T_1) and it was statistically at par with the treatments T_2 and T_3.

The minimum number of panicles m^{-2} was recorded in the crop without fertilizer (T_0). In the year 2013 the maximum percent filled grain was observed under the treatment T_1 and it was statistically at par with the treatments T_2 and T_3. In the year 2014 the percentage of grain filling was little bit more than the year 2013 and the maximum percentage of grain filling was obtained under the treatment T_1 and it was statistically at par with treatments T_2 and T_3. The lowest percentage of filled grain was recorded under the treatment T_0 in both the years. In the year 2013 the maximum grain yield was recorded under the treatment T_1 and it was statistically at par with the grain yields recorded under the treatments T_2 and T_3. The lowest grain yield was observed in the crop without fertilizer or manure (T_0). The magnitude of increase in yield was rather more in the year 2014. The maximum grain yield was obtained from the plots receiving the treatment T_1 and it was statistically at par with those recorded under the treatments T_2 and T_3. The minimum grain yield was noticed in the crop without fertilizer (T_0).

In the year 2013 the maximum straw yield was obtained from the crop fertilized with 100% organic through vermicompost (T_1) and this straw yield was statistically at par with the treatments T_2

and T_3. In the year 2014, the maximum straw yield was noticed under the treatment T_1 and it was statistically at par with the treatments T_2 and T_3, respectively. The lowest one was observed in case of T_0.

Table 2. Effect of different nutrient management on number of panicles m^{-2}, percentage of filled grain, grain yield and straw yield of rice grown under rice-lentil sequence

Treatment	First Year				Second Year			
	Number of panicles.m^{-2}	% filled grain	Grain yield (kg. ha^{-1})	Straw yield (kg.ha^{-1})	Number of panicles.m^{-2}	% filled grain	Grain yield (kg.ha^{-1})	Straw yield (kg.ha^{-1})
T_0	248.8	65.28	2387	3604	253.1	67.29	2463	3571
T_1	317.9	76.25	3414	4439	329.3	78.00	3667	4632
T_2	313.4	73.81	3367	4398	323.8	75.87	3562	4548
T_3	314.5	75.51	3380	4419	324.9	76.78	3581	4561
SEm (±)	3.86	1.471	29.9	32.5	3.06	1.234	37.9	33.6
CD(P = 0.05)	10.95	4.263	83.9	92.1	8.61	3.452	108.7	94.4

T_0- Without fertilizer or manure, T_1- 100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic + 50% chemical

Table 3 indicates that different parameters such as number of pods per plant, seed yield and stover yield of lentil grown during first year and second were significantly influenced by various nutritional management treatments. In the first year of experiment the highest number of pods per plant was recorded under the crop receiving 100% organic through vermicompost (T_1) and the highest number of pods per plant was closely followed by the treatments T_2 and T_3. The least number of pods per plant was noticed where the crop was treated with the treatment T_0. Similarly in the second year of investigation the maximum number of pods per plant was found where the crop received 100% organic through vermicompost (T_1) and this value was closely followed by the treatments T_2 and T_3. The minimum number of pods per plant was noticed where the crop was treated with the treatment T_0. This table also shows that the seed yield of lentil differed significantly with different nutritional management treatments in the year first year. The highest seed yield was observed from the treatment T_1 and it was statistically at par with the treatments T_2 and T_3. Similarly in the second year, the seed yield of lentil varied significantly with various nutritional management treatments (Table 3). But the magnitude of increase in yield was a little bit more in this year. The maximum seed yield was observed in the plots receiving 100% organic through vermicompost (T_1) and this value was statistically at par with the treatments T_2 and T_3. The lowest seed yield was recorded under the treatment T_0 in both the years. The treatment T_1 showed the maximum stover yield and it was statistically at par with the treatments T_2 and T_3. The minimum stover yield was obtained where the crop was treated with the treatment T_0 in both years.

Table 3. Effect of different nutrient management on number of pods per plant, seed yield and stover yield of lentil grown under rice-lentil sequence

Treatment	First Year			Second Year		
	Number of pods.plant^{-1}	Seed yield (kg.ha^{-1})	Stover yield (kg.ha^{-1})	Number of pods. plant^{-1}	Seed yield (kg.ha^{-1})	Stover yield (kg.ha^{-1})
T_0	37.2	452	1108	43.4	515	1248
T_1	62.6	783	1552	70.8	868	1741
T_2	60.5	734	1362	68.3	805	1630
T_3	62.0	767	1512	69.5	824	1648
SEm (±)	3.06	38.6	85.3	3.4	42.5	113.2
CD (P = 0.05)	8.89	109.3	240.7	9.84	118.2	321.5

T_0- Without fertilizer or manure, T_1- 100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic + 50% chemical

The Table 4 represents the pooled data of rice and lentil yield for consecutive two years of studies and yield was changed significantly with the change in nutritional management treatments. The maximum rice yield was recorded under treatment T_1 where rice crop was fertilized with 100% organic through vermicompost and it was statistically at par with the grain yields recorded under treatments T_2 and T_3. The lowest grain yield was observed in case of the treatment T_0. It was found that the application of 100% vermicompost (T_1), 100% chemical (T_2) and 50% organic + 50% chemical (T_3) increased the rice yield by 31.51%, 30.00% and 30.32%, respectively over control (the crop without fertilizer i.e. T_0). Similarly, it was noticed that the application of 100% vermicompost (T_1) and 50%

organic+ 50% chemical (T_3) increased rice yield by 1.69% and 2.15%, respectively over 100% chemical through fertilizer (T_2). In case of lentil the highest seed yield was obtained in treatment T_1 and it was statistically at par with the treatments T_2 and T_3. Lowest seed yield was observed in crop without fertilizer (T_0). Application of 100% vermicompost (T_1), 100% chemical (T_2) and 50% organic + 50% chemical (T_3) increased seed yield by 41.42%, 37.16% and 39.22%, respectively over control. Similarly, it was manifested that application of 100% vermicompost (T_1) and 50% organic + 50% chemical (T_2) has increased the seed yield by 3.63% and 6.78%, respectively over 100% chemical through fertilizer (T_2). This may be due to the fact that organic manure, like vermicompost is a nutritive plant food rich in NPK. These results are in accord with those observed by Bwamiki *et al*. (1998) and Maynard (1993).

Table 4. Effect of nutritional management on seed yield of rice and lentil (2 years' pooled data)

Treatment	Yield ($kg.ha^{-1}$)	
	Rice Grain yield (Kg ha^{-1})	Lentil Seed yield (Kg ha^{-1})
T_0	2425	483.5
T_1	3540.5	825.5
T_2	3464.5	769.5
T_3	3480.5	795.5
SEm (±)	33.7	40.49
CD (P = 0.05)	96.6	113.71

T_0- Without fertilizer or manure, T_1- 100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic + 50% chemical

From Table 5 it is clear that different Physical properties of soil have changed slightly at the end of the experiment (after two years) due to various treatments. In case of bulk density the lowest value was observed for the treatment T_1 and different other lower values were found under the treatments T_2 and T_3. The highest value of bulk density was observed in case of the treatment T_0. According to Miller *et al*. (2002) and Shirani *et al*. (2002) application of organic materials (manure and/or crop residues) can increase soil organic matter concentration and decrease bulk density. The treatment T_1 showed the maximum porosity followed by the treatments T_3 and T_2. The lowest value was observed in case of the treatment T_0. The highest percentage of capillary porosity was noticed in case of the treatment T_3 followed by the treatments T_0 and T_2. The lowest value was shown by the treatment T_1. The percentage of non-capillary porosity was the maximum in case of the treatment T_1 followed by the treatments T_3 and T_2. The percentage of non-capillary porosity was the minimum in case of the treatment T_0. Chenkai (1993) reported that incorporation of organic manures improved soil porosity. Table 5 also depicts that the maximum water holding capacity was the highest in case of the treatment T_1 and it was followed by the treatments T_3 and T_2. The treatment T_0 exhibited the lowest percentage of maximum water holding capacity. The treatment T_1 showed the minimum value of saturated hydraulic conductivity and different other lower values were found under the treatments T_3 and T_2. The highest value of saturated hydraulic conductivity was noticed in case of the treatment T_0. According to Anikwe (2000) soil organic manures influence the degree of aggregation and can reduce bulk density, increase total porosity and hydrualic conductivity of heavy clay soils.

Table 5. Physical properties of soil samples collected from experimental site (after harvesting of crops)

Treatment	Bulk Density (g cm^{-3})	Porosity (%)	Capillary porosity (%)	Non-capillary porosity (%)	Maximum Water Holding Capacity (%)	Saturated Hydraulic Conductivity ($cm.h^{-1}$)
T_0	1.65	36.8	24.5	12.3	36.01	1.05
T_1	1.42	46.0	21.58	24.42	45.02	0.04
T_2	1.64	36.9	24.09	12.81	37.44	0.5
T_3	1.52	40.04	26.95	13.09	43.02	0.32

T_0- Without fertilizer or manure, T_1- 100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic + 50% chemical

Initial physical properties of soil samples collected from experimental site - Bulk Density ($1.62g.cm^{-3}$), Porosity (37.07 %), Capillary porosity (26.24%), Non-capillary porosity (10.83%), Maximum Water Holding Capacity (35.02%), Saturated Hydraulic Conductivity ($1.02cm.h^{-1}$).

Table 6. Chemical properties of soil samples collected from experimental site (after harvesting of crops)

Treatment	Organic C (%)	Total N (%)	Available P (Kg ha^{-1})	Available K (Kg ha^{-1})
T_0	0.4	0.041	31.2	140.2
T_1	0.92	0.092	33.9	152.03
T_2	0.6	0.052	26.43	147.9
T_3	0.72	0.08	28.09	149.83

T_0- Without fertilizer or manure, T_1- 100% organic through vermicompost, T_2-100% chemical through fertilizer and T_3-50% organic + 50% chemical

Initial chemical properties of soil samples collected from experimental site- Organic C (0.48%), Total N (0.047%), Available P (32.84Kg ha^{-1}), Available K (142.5 Kg ha^{-1}).

From Table 6 it is clear that the treatment T_1 showed the highest percentage of organic carbon and it was followed by the treatments T_3 and T_2. The lowest value was shown by the treatment T_0. The percentage of total nitrogen was the highest in case of the treatment T_1 and it was followed by the treatments T_3 and T_2. The lowest percentage of total nitrogen was observed in case of the treatment T_0. The treatment T_1 showed the highest value of available phosphorus and it was followed by the treatments T_0, T_3 and T_2. The highest value of available potassium was tested in case of the treatment T_1 followed by the treatments T_3 and T_2. The lowest value was observed in case of the treatment T_0. Magdoff (1992) and Sahai (2004) reported that organic manure served as a reservoir of different types of nutrients which were essential for plant growth. According to Sudhakar *et al*. (2002) vermicompost contains micro sites rich in available carbon and nitrogen. Worm cast injected soils are also rich in water soluble phosphorous (Gratt, 1970) and contains two to three times more available potassium than surrounding soils (Sudhakar *et al*., 2002) which encourage better plant growth.

Conclusions

It has been found that the application of vermicompost showed better result in comparison to chemical fertilizers in terms of soil physical and chemical properties as well as productivity of soil. The preparation of vermicompost from organic wastes will save our environment as a whole, at the same time these wastes can also be managed properly. From this study it can be concluded that in comparison to chemical fertilizer, use of vermicompost is better from the point of view of all environmental aspects.

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