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Effect of bio-composts on soil fertility status and productivity of organic farm: An approach to promote sustainable agriculture

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Abstract: The findings of this research provide information on various approaches to manage and maintain soil fertility for organic crop production through composting. The initial recorded data pertaining to various conventional farming practices showed very low soil fertility status, low productivity before the initiation of organic farming. In the year prior to 2006 pH was low (4.10) and it increased to 5.40 by 2006-07. Organic carbon percentage increased to 1.35 in 2006-07 and the value of phosphorus was very low in the previous year but increased in the year 2006-07 (6.00 Kg/ha) while Potassium value increased in the year 2006-07 (395.00 Kg/ha). Input use pattern of various composts was also evaluated and it was observed that higher rates of FYM was used in case of maize-wheat+gram (614.31q/ha) in 2006-07 while higher rates of vermicompost was used in case of soybean-pea system i.e 111.11 q/ha for the year 2006-07. It was found that in the year 2006-07, among the cereals, yield of wheat was the highest (15.56 q/ha), among pulses soybean dominated (13.04 q/ha). The yield of potato (74.88 q/ha) was the highest among vegetable crops. For the year 2007-08, the yield of wheat+ lentil was the highest (10.86 q/ha). Among the pulses again yield of soybean was the highest (6.14 q/ha) and potato showed the highest yield among vegetables (73.88 q/ha). It showed that the application of compost had direct effect on productivity as the application of compost in the year 2007-08 decreased the productivity decreased subsequently as compared to initial year i.e 2006-07.

Keywords: Composting, Conventional, Organic, Vermicompost

INTRODUCTION

Worldwide, 1.9 billion hectares of land has significantly got degraded. Soils are less fertile, erosion has greatly increased and breakdowns in agro-ecological functions have resulted in poor crop yields, land abandonment and deforestation (IAASTD, 2008). Furthermore, chemical-based farming methods have led to human health risks. Pesticides have damaged wildlife, poisoned farm workers and created long-term health problems such as cancers and birth defects (Lichtenberg, 1992). The Green Revolution experiment focused on chemical crop fertility inputs, pest protection and weed control increasing toxicity in the environment while degrading planet's finite soil and water resources (Khan *et al.,* 2007). The organic farming methods such as crop rotations and associations, cover crops, organic fertilizers and minimum tillage increase the density and richness of indigenous invertebrates, specialized soil species, earthworms, symbionts and microbes. Such soil biodiversity enhances soil forming and conditioning, recycles nutrients, stabilizes soil against erosion and floods, detoxifies ecosystems and contributes to the carbon sequestration potential of soils while rotation of crops in organic systems functions as a tool for pest management and soil fertility. Organic farms generally have improved soils teeming with biodiversity, storing carbon and building humus (Hole *et al.,* 2005; Esperschütz *et al.,* 2007; Fließbach *et al.,* 2007; Niggli *et al.,* 2009; Zeiger and Fohrer, 2009; Niggli, 2010).

Organic agriculture practices rely to the maximum extent on crop residues, animal manures, crop rotations, green leaf manures, off-farm organic wastes and bio-fertilizers to supply plant nutrient. Compost is a rich source of organic matter which besides increasing soil organic matter, also plays an important role in sustaining soil fertility and sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil.

Sustainability of soil fertility and a steady increase in crop productivity are the priority areas to overcome food scarcity. The researchers concluded that organic farming can produce enough food to feed the world without increasing the agricultural land base. (Badgley *et al.,* 2007). The efficiency of the organic inputs in the promotion of productivity depends on the organic contents of the soil. Soil- bounded organisms often benefit because of increased bacteria populations due to natural fertilizer spread such as manure (Hole *et al*., 2005). Understanding the processes that take place within it is the basis for its sustainable management. Soil organ-

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isms influence every aspect of decomposition and nutrient availability (Magdoff and Van Es, 2000). One of the indirect benefits of organic management may be the build-up of a healthier soil. Van Bruggen and Semenov (2000) defined a healthy soil as a stable system, characterized by resilience to stress and having high biological diversity and a high level of nutrient cycling. Multiple studies showed increased microbial activity under organic farming. Mäder *et al.* (2002) and Van Diepeningen *et al.* (2006) found that organically managed soils were on the average more stable and healthier (Van Bruggen and Semenov, 2000) than their equivalent conventionally managed soils. Healthy soil from regenerative organic agriculture systems is the life-giving medium, the 'secret-sauce' for agricultural quality, productivity, restoration of environmental degradation and human health through more nutrient-dense food. The present study is a step forward in this very direction.

MATERIALS AND METHODS

The farm is located at CSKHPKV Palampur, India at $32^0$6'N latitude and $76^0$3'E longitude at an elevation of 1224 meters above mean sea level in the North Western Himalayas. Initially it was a barren land where conventional farming was done in the outskirts of university area. Its various components include- Vedic Krishi, Biodynamic and Homa Farming.

Soil analysis: Soil quality is the foundation on which organic farming is based. Composite soil samples were collected from the surface and digging profile of 0-15cm, 15-30 cm and 30-45cm. Samples were air dried in shade on ground, grinded in pestle and passed through 2 mm sieve and stored in cloth bags for further laboratory analysis. The various components of soil i.e soil pH, organic carbon, nitrogen, phosphorus, potassium etc. were analyzed over the period of two years:

Soil organic carbon (%) – (*Walkley and Black, 1934)*
Soil nitrogen (Kg/ha) – (*Subbiah and Asija, 1956)*
Soil phosphorus (Kg/ha) – (*Bray and Kurtz, 1954)*
Soil potassium (Kg/ha) – *(Stanford and English, 1949)*
Soil pH – (Jackson, 1973).

Input use pattern of bio-composts and productivity of crops: The data based on bio-composts and productivity was collected from the records that were maintained in the organic farm. Data was used to check and evaluate the effectiveness of various composts on soil fertility and the productivity of the farm.

RESULTS AND DISCUSSION

Soil parameters: In the year prior to 2006 pH was low (4.10) and it increased to 5.40 by 2006-07 while organic carbon percentage increased to 1.35 in 2006-07 as compared to low carbon percentage prior to 2006. Higher percentage value of nitrogen was estimated in the year 2006-07 (330.00 Kg/ha) as compared to the initial years. The value decreased slightly in the next year 2007-08 (255.20 Kg/ha). The value of phosphorus was very low in the previous year but increased in the year 2006-07 (6.00 Kg/ha). Potassium value increased in the year 2006-07 (395.00 Kg/ha). Similar findings have been given by Sujathamma *et al*. (2001) who emphasized on the supply of mineral nutrients to the soil for the maintenance of soil fertility by the use of organic manures. He concluded that though inorganic fertilizers showed quick results but their continued application adversely affected plant and soil health. Results showed that organic manures promoted microbial activity in the soil and improved its structure, aeration and water holding capacity which in turn improved the soil capabilities to respond to inputs. It is reported that soil under organic farming conditions had lower bulk density, higher water holding capacity, higher microbial biomass carbon and nitrogen and higher soil respiration activities compared to the conventional farms (Sharma, 2003). This indicated that sufficiently higher amounts of nutrients are made available to the crops due to enhanced microbial activity under organic farming. Beneficial effect of organic

Table 1. Soil fertility status of the farm.

Particulars	Year	Depth (cm)			
		Surface	0-15	15-30	30-45
pH	Prior to 2006	4.10	3.55	3.50	3.30
	2006-07	5.40	5.30	5.30	5.10
	2007-08	5.10	5.10	5.00	4.55
Organic carbon (%)	Prior to 2006	0.75	0.35	0.15	0.13
	2006-07	1.35	1.05	0.85	0.67
	2007-08	1.25	0.98	0.75	0.58
Nitrogen (Kg / ha)	Prior to 2006	185.40	171.40	150.80	150.00
	2006-07	330.00	290.00	275.00	255.00
	2007-08	255.20	242.40	235.00	209.10
Phosphorus (Kg / ha)	Prior to 2006	3.69	2.00	1.40	1.50
	2006-07	6.00	2.00	2.00	2.00
	2007-08	4.25	2.15	2.00	1.50
Potassium (Kg /ha)	Prior to 2006	210.00	201.00	195.00	155.00
	2006-07	395.00	359.00	449.00	268.00
	2007-08	345.00	323.00	310.00	268.00

Table 2. Input use pattern of different cropping systems of organic farm over two years (q/ha).

	FYM(q)			Vermi-compost(q)			Biodynamic compost(q)			Nadep compost(q)		
Cropping systems	**2006-07**	**2007-08**	**% de-crease**	**2006-07**	**2007-08**	**% de-crease**	**2006-07**	**2007-08**	**% de-crease**	**2006-07**	**2007-08**	**% de-crease**
1 Maize+soybean-wheat+lentil	164.70	143.18	-35.24	80.45	51.36	-3.48	24.24	24.70	0.90	0.00	0.00	0.00
2 Dhaincha-barley-mash-barley	400.00	308.45	-149.96	0.00	84.51	10.11	0.00	0.00	0.00	0.00	0.00	0.00
3 Setaria	16.85	0.00	-27.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 Dhaincha-linseed-soybean-linseed	202.18	428.57	370.82	101.09	0.00	-12.09	0.00	0.00	0.00	0.00	0.00	0.00
5 kulthi-barley-moong-barley	400.00	428.57	46.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 kulthi-barley-cowpea-barley	400.00	250.00	-245.70	0.00	75.00	8.97	0.00	0.00	0.00	0.00	0.00	0.00
7 cowpea-barley-cowpea-gram	414.29	250.00	-269.10	0.00	107.14	12.82	0.00	0.00	0.00	0.00	0.00	0.00
8 Moong-lentil-kulthi-lentil	400.00	388.89	-18.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 Mash-W+L-arhar+soybean-wheat	400.00	214.29	-304.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 Soybean-pea-ginger+maize-ginger	405.56	216.67	-309.40	111.11	0.00	-13.29	0.00	0.00	0.00	0.00	0.00	0.00
11 Soybean-peas-tomato-peas	403.45	465.52	101.67	51.72	0.00	-6.19	0.00	0.00	0.00	0.00	0.00	0.00
12 Soybean-palak-stevia-vegetables	400.00	465.12	106.66	58.14	58.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 Soybean-vegetables-soybean-peas	405.00	250.00	-253.89	0.00	125.00	14.95	0.00	0.00	0.00	0.00	0.00	0.00
14 Sunhemp-linseed-mash-linseed	200.00	393.26	316.56	96.07	0.00	-11.49	0.00	0.00	0.00	0.00	0.00	0.00
15 Dhaincha-potato-dhaincha-peas	400.00	20.11	-622.25	50.29	0.00	-6.02	25.29	0.00	-50.03	50.57	0.00	-45.56
16 Dhaincha-potato-dhaincha-potato	416.67	250.00	-273.00	25.00	145.83	14.45	25.00	0.00	-49.47	0.00	0.00	0.00
17 Dhaincha-gram-dhaincha-peas	328.57	357.14	46.80	25.00	0.00	-2.99	0.00	0.00	0.00	0.00	0.00	0.00
18 Dhaincha-guava+strawberry	324.22	46.58	-454.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19 Dhaincha-vegetables-soybean-wheat	411.54	211.54	-327.60	0.00	211.54	25.30	0.00	0.00	0.00	0.00	0.00	0.00
20 Maize+soybean-wheat+lentil-bhindi-wheat+lentil	400.00	422.22	36.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21Maize-wheat+gram-maize+soybean-wheat+gram	614.31	554.74	-97.56	87.59	0.00	-10.48	0.00	0.00	0.00	0.00	0.00	0.00
22 Paddy-wheat-rice-wheat	400.00	222.22	-291.20	0.00	222.22	26.58	0.00	0.00	0.00	0.00	0.00	0.00
23 Maize-wheat+gram-maize+soybean-wheat+gram	400.00	500.00	163.80	0.00	151.52	18.12	0.00	0.00	0.00	0.00	0.00	0.00

Contd…

Table 1. Contd…...

24 Maize-oats-charry-oats	286.95	521.74	384.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25 Charry-oats	300.00	493.98	317.73	0.00	0.00	0.00	0.00	0.00	0.00	50.12	0.00	-45.15
26 Maize-oats-bajra-oats	216.80	520.00	496.64	0.00	0.00	0.00	0.00	0.00	0.00	8.40	0.00	-7.57
27 Jowar-oats-bajra-oats	400.00	500.00	163.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 Dhaincha-vegetables-rice-wheat	311.11	222.22	-145.60	0.00	200.00	23.92	0.00	0.00	0.00	0.00	0.00	0.00
29 Soybean-pea-fallow-pea	300.00	200.00	-163.80	50.00	0.00	-5.98	0.00	0.00	0.00	0.00	0.00	0.00
30 Dhaincha-pea-soybean-pea	300.00	400.00	163.80	50.00	0.00	-5.98	0.00	0.40	0.79	0.00	0.00	0.00
31 Maize-wheat+gram	244.44	162.96	-133.47	58.67	58.67	0.00	11.85	11.85	0.00	0.00	0.00	0.00
32 Bajra-oats-mak.charry-oats	401.11	493.83	151.87	1.11	0.00	-0.13	1.11	0.00	-2.20	1.11	0.00	-1.00
33 Mak charry-oats-mak.charry-mollases	201.00	200.00	-1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34 Maize-shaftal-bajra-shaftal	200.00	476.19	452.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35 Bajra-redclover-charry+bajra-redclover	200.00	445.10	401.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36 Dhaincha-linseed-arhar-arhar	202.73	250.00	77.43	101.36	0.00	-12.12	0.00	0.00	0.00	0.00	0.00	0.00
37 Tagetus-pea	252.08	265.83	22.52	62.50	172.50	13.16	0.00	0.00	0.00	0.00	0.00	0.00
38 Dhaincha-carinata-arhar-arhar	411.67	208.33	-333.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39 Dhaincha-carinata-cowpea-linseed	406.67	416.67	16.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40 Dhaincha-linseed	415.65	173.91	-395.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41 Sunhemp-linseed-dhaincha-linseed	383.85	153.85	-376.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 Fallow-linseed-dhaincha-linseed	194.19	164.73	-48.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43 Charry-whiteclover-makka-whiteclover	206.09	308.70	168.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44 Fallow-redclover-makka-redclover	80.00	500.00	687.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45 Aloevera	151.40	0.00	-247.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46 Lemon-grass	122.53	0.00	-200.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47 Dhaincha-dhaincha-vegetables-gobi sarson	200.00	160.00	-65.52	0.00	171.25	20.48	0.00	0.00	0.00	0.20	0.00	-0.18
48 Maize-dhaincha-vegetables-gobi sarson	200.00	200.00	0.00	0.00	11.25	1.35	0.00	0.00	0.00	0.20	0.00	-0.18
49 Jowar-lucern-makka-lucern	252.38	642.86	639.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50 Maize-lucern-makka-lucern	254.74	473.68	358.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. Productivity of different cropping systems of organic farm over two years (q/ha).

Crops	Total compost (q/ha)	Total compost (q/ha)	Outturn (grains) (q/ha)			Outturn (straw) (q/ha)		
Cereals	**2006-07**	**2007-08**	**2006-07**	**2007-08**	**% change**	**2006-07**	**2007-08**	**% change**
Maize+soybean	172.71	199.01	6.13	6.89	0.9	40.27	24.29	-3.36
Wheat+lentil	186.63	116.36	12.69	10.86	-2.16	30.37	20.11	-2.16
Barley	201.57	212.12	7.4	3.54	-4.57	15.04	11.82	-0.68
Wheat+gram	148.51	184.36	9.91	8.45	-1.73	28.37	16.83	-2.42
Paddy	403.7	0	8.89	4.63	-5.04	38.89	9.44	-6.18
Wheat	200	207.55	15.56	4.57	-13	55.56	6.04	-10.4
Jowar	202.03	0	0	0	0	180.51	0	-37.91
Maize	210.3	88.61	5.64	6.52	1.04	78.33	13.33	-13.6
Bajra	200	253.97	0	0	0	99.65	48.10	-10.83
TOTAL	1925.45	1261.98	66.22	45.46	---	---	---	---
Pulses								
Gram	200.00	275	1.07	0.18	-1.05	0	0	0
Soybean	265.24	192.37	13.04	6.14	-8.16	40.42	12.77	-5.81
Moong	200.00	214.29	0.56	0.43	-0.15	3.15	1.43	-0.36
Lentil	200.00	185.19	2.50	2.22	-0.33	13.52	0	-2.84
Mash	267.57	117.12	2.19	0.26	-2.28	6.10	1.69	-0.93
Kulthi	200.00	203.7	3.07	1.11	-2.32	5.18	2.41	-0.58
Cowpea	268.50	75.76	0.71	1.21	0.59	27.14	3.03	-5.06
Peas	179.67	206.37	---	---	---	33.45	14.18	-4.05
Arhar	0	114.13	0	0.65	0.77	0	0	0
Arhar+soybean	0	23.81	0	4.76	5.63	0	7.62	1.60
TOTAL	1780.98	1607.74	23.14	16.96	---	---	---	---
Fruits-veg								
Fruits	124.22	23.29	0.54	4.50	4.68	0	0	0
Vegetables	178.61	101.16	38.41	45.37	-9	0	0.48	0.10
Potato	121.1	350.22	74.88	73.68	-1.41	0	0	0
TOTAL	423.93	474.67	113.83	123.55	---	---	---	---

sources such as FYM, crop residues and compost on soil properties and profitable crop yield has been well documented. Compost is a rich source of macro-and micronutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora (Bhawalker, 1991). Rivero *et al.* (2004) suggested that compost increases the quality of the soil organic matter by contributing to a higher level in the soil of the most beneficial humic substances, which may change the balance between beneficial and detrimental micro-organisms. It was reported that soil under organic farming conditions had lower bulk density, higher water holding capacity, higher microbial biomass carbon and nitrogen and higher soil respiration activities compared to the conventional farms because of organic management practices as composting (Sharma, 2003). According to Raviv *et al.* (2006) in the Israeli conditions, in addition to the beneficial effect on soil biological and physical properties, compost is the only required source for both K and P and also an important source for N. Being of extra value for organic farming, it was found that the compost type could efficiently suppress several soil-borne diseases (Aryantha *et al*., 2000; Reuveni *et al.,* 2002; Raviv *et al*., 2005; Saadi *et al.,* 2010). Composts frequently applied to organically managed soils were presumably the main reason for the repeatedly observed greater biological activity in organic soils as compared with conventionally managed soils (Gunapala and Scow, 1998; Leita *et al.,* 1999; Carpenter-Boggs *et al.,* 2000).

Input use pattern of bio-composts: The input use pattern in different cropping systems on organic farm has been presented in Table 2. Higher rates of FYM was used in case of maize-wheat+gram (614.31q/ha) in 2006-07 while higher rates of vermicompost was used in case of soybean-pea system i.e 111.11 q/ha in the same year. In the year 2006-07 biodynamic compost (25.29 q/ha) and nadep compost (50.57 q/ha) were used in dhaincha-potato system. However, lesser quantities (as compared to 2006-07) of FYM and composts were applied in the year 2007-08 with the exception of vermicompost which was applied mostly in rice-wheat system (222.22 q/ha) in 2007-08. Higher rates of FYM was used in cowpea (207.14 q/ha) in the year 2006-07 followed by vermicompost (203.7 q/ha) in paddy and bio-dynamic compost (7.93 q/ha) in wheat+ lentil in the same year. In the year 2007-08 higher rates of FYM was used in makka (306.67 q/ha) whereas rate of vermicompost used was higher in paddy (203.7 q/ha) and potato (92.11 q/ha). Use of biodynamic compost was also the highest in potato (25.12 q/ha) for the year 2007-08. Schmutz *et al*. (2007) also emphasized on the importance of organic inputs in income generation and without livestock manure inputs, nutrient supply generated only costs and no income. Kumar *et al*. (2007) also recorded higher yield of rice-wheat with the use of organic manures. Composting cannot be considered a new technology, but amongst the waste management strategies it is gaining interest as a suitable option for manures with economic and environmental profits, since, this process eliminates or reduces the risk of spreading of pathogens, parasites and weed seeds associated with direct land application of manure and used to improve and maintain soil quality and fertility (Larney and Hao, 2007; Pullicinoa *et al*., 2009).

Productivity of different crops: The productivity of different crops on the organic farm has been displayed in Table 3. It can be clearly visualized that in the year 2006-07, among the cereals, yield of wheat was the highest (15.56 q/ha), among pulses soybean dominated (13.04 q/ha). The yield of potato (74.88 q/ha) was the highest among vegetable crops. For the year 2007-08, the yield of wheat+ lentil was the highest (10.86 q/ha). Among the pulses again yield of soybean was the highest (6.14 q/ha) and potato showed the highest yield among vegetables (73.88 q/ha). As the application of compost in the year 2007-08 decreased the productivity decreased subsequently as compared to initial year i.e 2006-07. Similar results were seen by Delate *et al.* (2003) who reported that yields and overall economic returns in organic farming systems were higher in corn and soybean crops over conventional farming at the Neely-Kinyon Long-Term Agroecological Research site in Iowa, measured over a three-year period. Singh *et al.* (2001) recording the experiments on rice-chick pea cropping sequence using organic manure, found the yields substantially higher compared to the control group. Similar results were obtained for rice, ginger, sunflower, soyabean and sesame. Integration of FYM and *Azotobacter* with N, productivity and monetary returns of wheat can be increased by maintaining or improving soil fertility (Sarma *et al.* (2007). Singh and Singh (2005) also reported 29.9, 18.8, 35.5 and 15.2% increase in yield owing to FYM application at 15 t ha^{-1} and vermi-compost at 7.5, 10 and 15 t ha^{-1}, respectively over no organic manure. Yadav (2005) also reported that organic practices improved soil health.

Conclusion

The organic management practices especially use of various organic composts, green manuring, and incorporation of leguminous crops improved the overall fertility status of the soil. The productivity was found to increase with increased input of biodynamic compost, FYM, Nadep compost and Vermi-compost. Such organic systems render to be sustainable agricultural production systems in a longer run with increased soil and human health.

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