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Vermicompost as soil supplement to enhance growth, yield and quality of *Triticum aestivum* L.: a field study

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Abstract

Background: Vermicompost (VC) made from cattle dung as raw material was used as soil supplement in the plots of size 4.5 x 4.5 m. Five treatments were given *viz.* Soil (control), VC@5 t/ha, VC@10 t/ha, VC@20 t/ha and NPK (recommended by PAU, Ludhiana) in triplicates in a Randomized Block Design (RBD). A total of 50 plants were selected randomly for the assessment of growth and yield of wheat *Triticum aestivum* L..

Results: Most of the growth, yield and quality parameters were found to be maximum in NPK treatment. All the growth, yield and quality parameters in vermicompost treatments varied significantly from control though differences within various vermicompost treatments were not found to be significant.

Conclusion: It has been observed that there is no significant difference on applying higher doses of vermicompost and lowest dose (5 t/ha) is as effective as higher doses. So, vermicompost application is cost effective.

Keywords: Vermicompost; Plant growth; Earthworm; *Triticum*; Plants quality

Introduction

In India, one third of the total food grains production is contributed by wheat and it is second most common crop of the country. At world level, India carries second place among wheat growing countries in terms of area and production. Wheat flour is used to make "*chappati*" which is its most common consumable form in India. Cattle are fed using wheat straw (ICAR 2009). Agricultural production of India increased remarkably during 60s to 80s as a result of "Green revolution" (Gupta 1996). India could achieve self-sufficiency in agriculture by an increased use of chemical fertilizers. These agrochemicals deteriorate soil health and environment got polluted. Human beings and cattle were adversely affected due to the residues of these agrochemicals in food products (Kumar and Bohra 2006). So, organic manures like vermicomposts can be a good substitude for chemical fertilizers to overcome their adverse effects. Vermicomposts are finely-divided mature peat-like materials which are produced by a non-thermophylic process involving interactions between earthworms and microorganisms (Edwards and Burrows, 1988) leading to bioxidation and stablisation of organic material (Aira et al., 2000). Vermicomposts are effective organic fertilizers and biocontrol agents (Edwards and Arancon 2004; Simsek-Ersahin 2011). Vermicomposts can improve food quality without compromising with food safety (Simsek-Ersahin 2011). Both developed and developing countries are using vermicomposting during last 40 years (Edwards 1995; Simsek-Ersahin 2011). Applications of vermicompost singly or in combination with either other organic fertilizers or chemical fertilizers have been proved effective to enhance growth and yield of various plants like Urad and Soyabean (Javed and Panwar, 2013), Setaria grass (Sabrina et al. 2013), Lilies (Mirakalaei et al. 2013), Marigold (Paul and Bhattacharya 2012), *Matricaria chamomomomile* (Hadi et al. 2011), *Abelmoschus esculentus* (Vijaya and Seethalakshmi 2011), *Chysanthemum morifolium* (Verma et al. 2011), French bean (Singh et al. 2011), Geranium (Chand et al. 2011), Groundnut (Mycin et al. 2010), Okra (Ansari and Kumar Sukhraj 2010), Cucumber (Azarmi et al. 2009; Sallaku et al. 2009), Tomato (Lazcano et al. 2009), *Amaranthus sp.* (Uma and Malathi 2009), Garlic (Suthar 2009), *Andrographis paniculata* (Vijaya et al.

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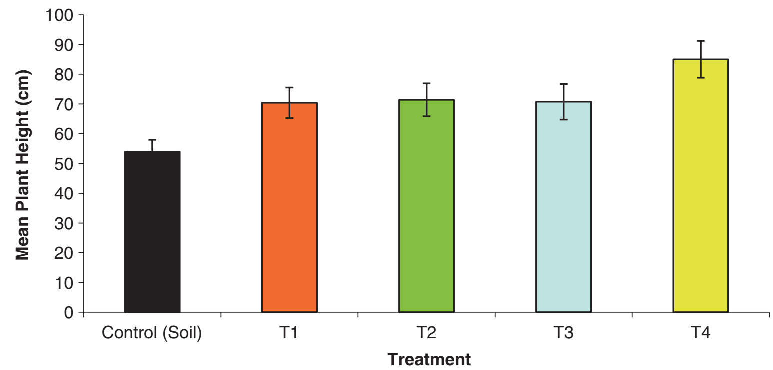

Figure 1 Comparison of mean plant height (cm) in different treatments.

2008), Strawberry (Singh et al. 2008), Spinach (Peyvast et al. 2008), Maize (Gutie'rrez-Miceli et al. 2008), Sorghum (Hameeda et al. 2007), Lettuce (Ali et al. 2007) and Potato (Alam et al. 2007). So present study was designed keeping in view the harmful effects of agrochemicals and need for organic farming.

The main objectives of the field experiment was:

1) to prepare vermicompost using cattle dung and checking its efficiency as an organic fertilizer for application on wheat.
2) to access the effect of different rates of vermicompost on a) growth b) yield and c) quality of wheat.
3) to compare the growth, yield and quality of wheat using vermicompost and NPK fertilizers.

Methods

Preparation of vermicompost

Cattle Dung (CD) was used as raw material to prepare vermicompost (VC). Beds of size 5 feet × 2 feet were prepared with the help of bricks under a shed open from all sides in the Botanical Garden of Guru Nanak Dev University for vermicomposting of Cattle dung (CD). VC was harvested after 40 days and it was analyzed for physico-chemical characteristics like pH, Total Kjeldhal Nitrogen (Bremner and Mulvaney 1992), Total Available Phosphorus (John 1970), Total Potassium (TK) and Total Sodium (TNa) by Flame photometer, Total Organic Carbon (Nelson and Sommers 1982) and Electric Conductivity (Electrometric Method). Physico-chemical parameters for vermicompost and soil are given in Table 1.

Field preparation

Experimental field was prepared in the Botanical garden of Guru Nanak Dev University to grow wheat in a two year field trial during Nov-April *2008*–09 and 2009–10. Field was ploughed and levelled with the help of tractor. A total of 15 plots of size 4.5 m × 4.5 m were prepared.

Treatments of vermicompost and NPK fertilizers

Five treatments were made as given in Table 2. All the treatments were given in triplicates in a Complete Randomized Block Design.

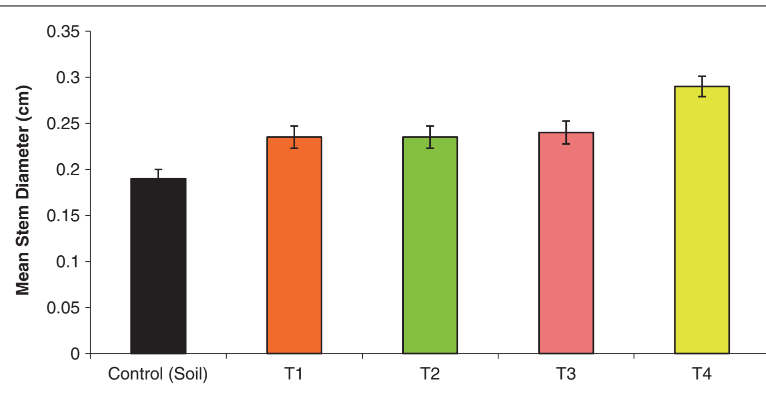

Figure 2 Comparison of mean stem diameter (cm) in different treatments.

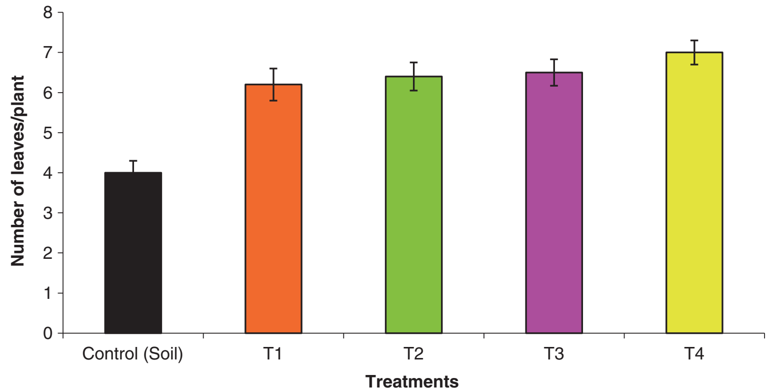

Figure 3 Comparison of number of leaves/plant in different treatments.

Variety of seeds used and cultivation of wheat

Certified seeds of variety PBW 373 produced by Punjab Agricultural University (PAU), Ludhiana were used in the experiment. This variety is sown in the end of November after the harvesting of crops like Basmati rice and Potato on a large area of Punjab each year. Wheat was cultivated according to package of practices issued by PAU, Ludhiana. Seeding was done at a rate of 40 kg/acre with a spacing of 20 cm between rows. 1st irrigation was done after 5 weeks of sowing. 2nd irrigation was done after 3 weeks of previous irrigation. 3rd irrigation was done after 2 weeks of previous.

Sampling and data collection

Various growth and yield parameters were recorded after every 30 days. A total of 150 plants were selected randomly from each treatment (50 from each plot) for the assessment of mean plant height (cm), mean stem diameter (cm), number of leaves/plant, number of spikes/plant, spike length/plant (cm), number of spikelets/spike/plant and yield/acre. Plant height was recorded using scale. Stem diameter were recorded using vernier calliper. Yield obtained from plots of five different treatments were stored in five different jute bags. Yield was weighted using a weighing balance. Quality parameters i.e. Protein content (%), Fat content (%), Dietary Fibers (%), Moisture content (%), Ash content (%) and Carbohydrate content (%) were analysed using AOAC methods (AOAC 1990).

Statistical analysis

The experimental data was expressed as mean ± S.E, one way analysis of variance (ANOVA) and LSD test was carried out using SPSS to determine significant differences from the control ($p \leq 0.05$).

Result and discussion

Growth and yield parameters

Height of wheat plant was maximum in T_4 (85 cm) treatment with NPK dose while it was minimum in T_1 (70.4 cm) treatment. Plants height in treatment T_1, T_2, T_3 and T_4 were significantly greater than plant height of 54 cm reported in soil (control) as shown in Figure 1. Significant differences did not exist between T2, T3 and T4 due to salinity stress on adding higher concentrations of vermicompost. Growth and development of plants is

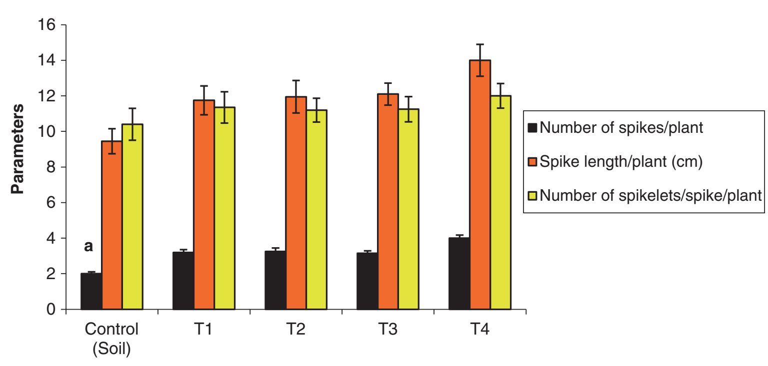

Figure 4 Comparison of number of spikes/plant, spike length/plant (cm) and number of spikelets/spike/plant in different treatments.

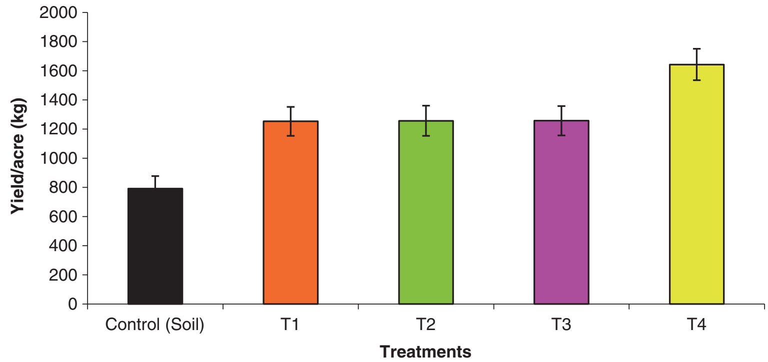

Figure 5 Comparison of yield/acre (kg) in different treatments.

due to the presence of humic acids (Arancon et al. 2005) and micro and macronutrients in vermicompost (Atiyeh et al., 2002; Fernández-Luqueño et al. 2010). The maximum increase in plant height of *Matricaria chamomomile* was observed by (Hadi et al. 2011) when vermicompost was applied at the rate of 20 t/ha. Plant height of maize plant increased significantly as compared to control when grown in peat moss amended with vermicompost supplemented with different concentrations of mycorrhizas (*G.fasciculatum* and *G.claroideum*) and diazotrophic bacteria (Gutie'rrez-Miceli et al. 2008). Similiarly, vermicompost amendments increased plant heights of potato *Abelmoschus esculentus* was reported by (Alam et al. 2007; Vijaya and Seethalakshmi 2011 respectively).

Stem diameter (cm) was also observed to be significantly higher in four treatments 0.235 (T_1), 0.235 (T_2), 0.24 (T_3), and 0.29 (T_4) than control (0.19) as shown in Figure 2. In similar studies, application of vermicompost increased stem diameter of Lilium plant (Moghadam et al. 2012) and okra (Ansari and Kumar Sukhraj 2010).

A significant increase was observed in number of leaves in four treatments (6.2, 6.4, 6.5, and 7.0) as compared to control (4.0) as shown in Figure 3. It may be due to that more plant-available form of nitrogen (nitrate) is high in vermicompost than conventionally composted manure (Taleshi et al. 2011). In a study, Azarmi et al.2009 reported that leaf dry weight, chlorophyll content and number of leaves of cucumber increased on vermicompost applications. Atiyeh et al. (2002) reported that use of maize plants as forage depends upon number of leaves and the wet weight of maize plants and number of leaves increased on application of vermicompost.

Number of spikes/plant was more in T_4 treatment (4) than control and other treatment of vermicompost doses. It was 3.2 in T_1, 3.25 in T_2 and 3.15 in T_3 treatment. Spike length/plant (cm) in treatments T_1, T_2, T_3 and T_4 were found to be 11.75, 11.95, 12.1 and 14 respectively, which were significantly greater than spike length/plant of 9.45 reported in Soil (control). Number of spikelets/spike/plant was also observed to be significantly higher in four treatments in T_1 (11.35), T_2 (11.2), T_3 (11.25) and T_4 (12) than control (10.4) as shown in Figure 4. Salinity stress due to alkaline pH of vermicompost and presence of ions in vermicompost may be the reason for no significant differences between different vermicompost treatments. Raw material used to prepare vermicompost, microorganisms and amount of nutrients affect the efficiency of vermicompost as a plant growth enhancer (Jack and Thies 2006; Hameeda et al. 2007).

Total yield/acre of wheat in soil came out to be 792.5 kg while it came out to be 1253.5 kg, 1257.5 kg, 1258 kg and 1643 kg in treatments T_1, T_2, T_3 and T_4 respectively. A significant increase was observed in 1000 grains weight (g) in four treatments and it was 41.75 g in T_1, 41.1 g in T_2, 40.45 g in T_3 and 43.0 g in T_4 as compared to control (39.0 g) as shown in Figure 5. In similar studies, increases in yields by vermicompost applications in okra, strawberry, eggplant, potato, cucumber cultivars, *Abelmoschus esculentus*, peppers, crossandra, lettuce, *Amaranthus species* were reported by Ansari and Kumar Sukhraj 2010, Singh et al. 2008, Moraditochaee et al. 2011, Alam et al. 2007, Azarmi et al. 2009, Vijaya and Seethalakshmi 2011, Arancon et al. 2005, Gajalakshmi and Abbasi 2002, Papathanasiou et al. 2012 and Uma and Malathi 2009 respectively. Availability of nitrogen increases growth and

Table 1 Various physico-chemical parameters of vermicompost and soil (Mean ± S.E)

Parameters analyzed	Vermicompost	Soil
pH	8.1 ± 0.03	7.9 ± 0.01
EC (mS cm^{-1})	391± 0.66	156 ± 3.1
TKN (g kg^{-1})	9.12 ± 0.61	0.6 ± 0.09
TAP (g kg^{-1})	5.7 ± 0.5	1.5 ± 0.09
TK (g kg^{-1})	25.4 ± 0.8	0.21 ± 0.01
TNa (g kg^{-1})	23.1 ± 0.15	0.12 ± 0.009
TOC (g kg^{-1})	229 ± 0.1	5.0 ± 0.001

Table 2 Vermicompost and NPK doses in different treatments

Treatment	Vermicompost dose
Soil (Control)	No vermicompost
T_1	VC@ 5 t/ha
T_2	VC@ 10 t/ha
T_3	VC@ 20 t/ha
T_4	NPK (recommended)

leaf area index of plant which in turn increases absorption of light leading to more dry matter and yield (Nanda et al. 1995, Ravi et al. 2008, Taleshi et al. 2011). Vermicompost increased growth and yield of various plants because of high porosity, aeration, drainage, and water-holding capacity (Edwards and Burrows 1988), presence of beneficial microflora (Tomati et al. 1987), nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Orozco et al. 1996) and Plant growth regulators (Tomati et al. 1988; Grappelli et al. 1987).

Quality parameters

Protein content (%) in all the four treatments (10.9, 11.1, 11.3 and 13) showed a significant increase as compared to Control. It was maximum in T_4 (13.0%) then 10.9% in $T_{1,}$ 11.1% in T_2 and 11.3% in T_3 treatment. Protein content was minimum 9.0% in control (Table 3). Vermicompost prepared from parthenium weed increased total soluble protein (%) of *Abelmoschus esculentus* as compared to control (sole soil) and soil amended with recommended dose of chemical fertilizers (Vijaya and Seethalakshmi 2011). Vijaya et al. 2008 found that amending garden soil with coir pith vermicompost increased the protein content of *Andrographis paniculata* as compared to control (graden soil). Protein (%) of okra (*Abelmoschus esculentus*) increased in combined treatment of vermicompost and vermiwash as compared to control (soil), Vermiwash alone and vermicompost alone (Ansari and Kumar Sukhraj 2010).

Fat content in all the four treatments 1.0%, 1.1%, 1.2% and 1.25% in T_1, T_2, T_3 and T_4 respectively were observed to be significantly higher than control (0.97). Crude fibres in treatments T_1, T_2, T_3 and T_4 came out to be 1.3%. 1.33%, 1.3% and 1.4%, which were lower than control (1.2%). Fat content of okra (*Abelmoschus esculentus*) increased in combined treatment of vermicompost and vermiwash as compared to control (soil), Vermiwash alone and vermicompost alone (Ansari and Kumar Sukhraj 2010).

A higher content of Ash was recorded in four treatments and it was maximum in T_4 (1.11%) and minimum in control (0.76%). Ash content in T_2 treatment was 0.82%, in T_3 0.9% and this increase was significant as compared to control. Bulk density (g/cm^3) in all the four treatments showed a significant increase as compared to Control and it was 0.165, 0161, 0.163, 0.171and 0.151 respectively in T_1, T_2, $T_{3,}$ T_4 and Control (soil). Moisture content (%) of all the four treatments (13.3, 13.5, 13.8 and 13.8) was observed to be significantly higher than control (12.1). Moisture content was maximum 13.8 in T_3 and T_4 treatment and minimum 12.1 in control while it was 13.3 in T_1 13.5 in T_2 treatment.

Carbohydrate content in treatments T_1, T_2, T_3 and T_4 came out to be 72.68%, 71.9%, 71.5% and 69.91% which were not significantly lower than control (75.97). Vermicompost prepared from parthenium weed increased total soluble carbohydrates (%) of *Abelmoschus esculentus* as compared to control (sole soil) and soil amended with recommended dose of chemical fertilizers (Vijaya and Seethalakshmi 2011).

Conclusion

Organic manures are slow leaching and have to be applied in bulk because of their lower N, P and K content. Applying organic manures like vermicomposts in bulk raises economical concerns in the minds of farmers who wish to opt for organic farming. In the present study, it has been observed that there is no significant difference on applying higher doses of vermicompost and lowest dose (5 t/ ha) is as effective as higher doses. So, vermicompost application is cost effective. Moreover, it may take more than two years time for an organic farm to improve the soil health enough to make the growth and yield equivalent to chemical fertilizers. Futher studies with a trial period of more than two years are needed in future for this. In India, thousand tons of grains get destroyed every year due to lack of storage

Table 3 Quality parameters of wheat in different treatments

Treatments	Protein (%)	Fat (%)	Dietaryfibers (%)	Moisture (%)	Ash (%)	Carobhydrates (%)
Soil (Control)	9 ± 0.39**a**	0.97 ± 0.02**x**	1.2 ± 0.05**p**	12.1 ± 0.5**a**	0.76 ± 0.05**x**	75.97 ± 3.1**p**
T_1	10.9 ± 0.37**b**	1.0 ± 0.023**y**	1.3 ± 0.045**q**	13.3 ± 0.45**b**	0.82 ± 0.049**y**	72.68 ± 2.95**q**
T_2	11.1 ± 0.41**b**	1.1 ± 0.024**y**	1.33 ± 0.049**q**	13.5 ± 0.4**b**	0.9 ± 0.044**y**	71.9 ± 2.89**q**
T_3	11.3 ± 0.5**b**	1.2 ± 0.023**y**	1.3 ± 0.05**q**	13.8 ± 0.44**b**	0.9 ± 0.041**y**	71.5 ± 2.71**q**
T_4	13 ± 0.46**c**	1.25 ± 0.019**z**	1.4 ± 0.044**r**	13.8 ± 0.39**c**	1.11 ± 0.039**z**	69.61 ± 2.6**r**

Values followed by same letters in a column are not significantly different ($P \leq 0.05$).

facility. If we provide proper storage facilities, the yield loss which occurs during initial years in an organic farm may be recovered. Moreover, Consumer health, harmful effects of agrochemicals and over-populations are bigger issues than yield loss. So, the result of present study proves economical viability of applying vermicompost and suggests the need for longer field trials in future.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

RJ: made highest contribution in designing, measuring of field parameters, chemical analysis of soil and vermicompost, analysis of quality parameters. APV: Provided resources, helped in designing, participated in measurement of field parameters, analysis of quality parameters and preparing the draft of manuscript. JS: participated in chemical analysis of soil, vermicompost and helped in preparing the draft of manuscript. All authors read and approved final manuscript.

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