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ORIGINAL RESEARCH

Comparison of vermiwash and vermicompost tea properties produced from different organic beds under greenhouse conditions

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Abstract

Purpose Using different organic beds to produce vermicompost may influence on quality of vermicompost and its derived productions.

Methods A greenhouse experiment was conducted to compare the properties of vermicompost, vermiwash and vermicompost tea obtained from three types of organic beds consisted of cow manure, leaf meal and a combination of cow manure and leaf meal (1:1 w/w).

Results Cow manure vermicompost had more desirable effect on many measured traits toward leaf meal and combination of leaf meal and cow manure vermicomposts. Vermicompost tea obtained from three vermicompost types was richer in terms of macro and micro nutrients, C/N, percent of organic matter and organic carbon toward the vermiwash produced from the same vermicompost. Vermiwash and vermicompost tea produced from cow manure vermicompost were at first order in majority of measured traits toward others.

Conclusions Generally vermicompost which was richer in nutrient concentrations affected intensively quality of vermiwash and vermicompost tea produced from it.

Keywords Vermicompost · Liquid organic fertilizers · Organic beds

Introduction

Industry of domestic animals production, especially industrial dairies have led to produce an enormous value of organic wastes so far. Cow manure and leaf meal are the most widely used as bed ingredients in greenhouse cultures in Iran. These organic wastes can be useful to apply in enhancing soil physicochemical properties and fertility (Bansal and Kapoor 2000). One of the most important methods of processing organic wastes is recycling it as an organic fertilizer. Not only this process reduces sanitary and environmental problems, but also a great value of organic fertilizer is produced during it. For this, using earthworms has a specific role to produce organic fertilizer from waste named vermicompost (Suthar and Singh 2008). Vermicompost is an eco-friendly non-toxic that consumes low energy input for composting and is a recycled biological product. The major advantages of vermicompost are desirable smell, balanced pH, low electrical conductivity, high cation exchange capacity, concentrations of available nutrients and plant growth promoting microorganisms. Vermicompost has been considered as a material containing plant growth promoting compounds including enzymes, different hormones and so many other unspecified compounds (Atiyeh et al. 2002). Orozco et al. (1996) stated that vermicompost is more sustainable than primary parent materials and its nutrients are more available. Because vermicomposting through earthworms is an eco biotechnological process that transforms energy rich and complex organic substances into a stabilized vermicompost (Benitez et al. 2000). These materials cause useful changes in plant growth bed which leads to increase

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plant growth. All useful changes occur because of mutual interaction between microorganisms and earthworms (Gallardo-Lara and Nogales 1987; Marinari et al. 2000).

Vermiwash is the liquid gathered by passing water among a path of soil containing active worms and organic bed. It is a combination of earthworm mucous discharges, nutrients, microorganisms and plant growth promoting materials (Gopal et al. 2010). Vermiwash is produced by different methods in which, it is assumed that microbial activities and nutrients are transformed from vermicompost into its extraction. This liquid partially comes from body of earthworm (as worms body contains plenty of water) and is rich in amino acids, vitamins, nutrients like nitrogen, potassium, magnesium, zinc, calcium, iron, and copper and some growth hormones like auxins and cytokines (Suthar 2010a). There are some strong evidences proving that vermiwash have impressive benefits, but these benefits are dependant on quality of used substrate producing vermiwash (Scheuerell and Mahaffee 2002). Vermiwash considers a biotic aqua fertilizer which is applied as pesticides and also contains plant essential nutrients. Vermiwash has anti-spawning effects on insects (Zhu et al. 2001). Leaf nutrition with vermiwash obtained from municipal wastes improved the photosynthesis activity, plant physiology and performance (Astaraei and Ivani 2008).

Nath et al. (2009) reported that vermiwash amended with phytohormones, enzymes and vitamins improved plant growth and yield and also increased plant resistance against different diseases. The results of Quail and Ibrahim (2013) indicated that for mung bean (*Vigna radiate* L.), using leached vermicompost and vermiwash, germination was higher in 10% vermiwash than in treatment with 10% vermicompost leachate.

Generally, vermicompost elutriate (vermicompost tea) is produced by placing a defined quantity of vermicompost into water and shaking it for a defined period of time. Vermicompost is the main component of vermicompost tea and the source and quality of used vermicompost is one of the main points in this regard (Scheuerell and Mahaffee 2004). It was reported that the effects of vermicompost tea and vermicompost are the same (Edris et al. 2003; Quial and Ibrahim 2013; Edwards et al. 2006). Unlike vermicompost, vermicompost tea can be applied on plant directly. Application of vermicompost tea as a foliar application causes to promote the growth of many healthy plants, increases plants sustainability against pests and diseases and accelerates degradation of toxic materials. Organic tea usage leads to increase in power and plant resistance toward bacteria and fungi diseases and this is due to existence of micro and macro-nutrients, hormones, vitamins, plant enzymes and also organic chelating factors which increase nutrients availability (Merrill and McKeon 1998). Unlike vermicompost, diluted vermicompost tea is applied sometimes in soil and sometimes in foliar spray but its worth as a nutritional treatment has not been determined yet (Gaskell et al. 2000). Many liquid fertilizers and organic tea are capable of providing essential micronutrients which can be either injected to every irrigation system or used in foliar application (Gaskell et al. 2000). Using different organic beds to produce vermicompost may influence on the quality of vermicompost and its derived productions. This research aimed to assess the effect of different beds of vermicompost on quality of vermiwash and vermicompost tea obtained from it. Considering to existed the enormous value of cow manure and leaf meal, these two resources were selected in this research and the properties of vermicompost, vermiwash and vermicompost tea produced from them were compared with standard methods together in greenhouse condition.

Methods

Organic beds sources

In this experiment, considering the enormous value of cow manure and leaf meal, these two resources were selected. Cow manure and leaf meal were provided from animal husbandry station and green space at College of Agriculture, Shiraz University, Iran, respectively. These materials were pre composted for 1 month. While preparing leaf meals, leaves are air-dried, and then ground and stored in sacks. Some chemical properties of pre composted cow manure and leaf meal were measured with standard methods and are presented in Table 1.

Table 1 Some properties of used leaf meal and cow manure

Parameters	Leaf meal	Cow manure	Leaf meal:cow manure (1:1)
pH	8.07	8.26	8.19
EC (dS/m)	1.03	2.34	1.56
OM (%)	42.7	61.8	52.1
OC (%)	24.7	35.8	30.2
C/N	45.9	35.1	34.7
Fe (mg/kg)	334	956	678
Mn (mg/kg)	52.4	85.4	67.5
Cu (mg/kg)	2.16	5.60	3.15
Zn (mg/kg)	25.3	65.6	41.4
N (%)	0.54	1.02	0.87
P (mg/kg)	879	1243	1056
K (mg/kg)	998	2567	1456

Production of vermicompost, vermiwash and vermicompost tea

The experiment was conducted in a greenhouse with day/night temperature of 24 ± 3 °C/15 ± 3 °C, 60–70% average relative humidity (RH) and a photoperiod of 16 (h) with photosynthetic photon flux (PPF) of 800 μmol/m^2/s.

To produce organic fertilizers, plastic containers were selected. A hole at the base of the each container drilled to fix a valve to it. A base layer of gravel to a height of 5 cm and above it a 2 cm layer of coarse sand were put. On the coarse sand layer, 1000 g pre-decomposed each organic bed was placed and moistened the different layer using water. Combinational bed was prepared with mixing leaf meal and cow manure at the ratio of 1:1 by weight. Thirty numbers of live weight of clitellated and young non-clitellated of *Eisenia foetida* earthworms (approximately 17 g live weight) were introduced into each bed. Earthworms were provided from vermicompost field in College of Agriculture, Shiraz University, Iran. There was a wicker cover creating shadow on the bed of earthworms' activity. During the whole process, moisture content was maintained at 75 ± 5% by pouring non-chlorinated tap water into each bed. Excessive latexes were exited via improvised valve below the container. After 45 days, vermiwash was collected in a period of 15 days by valve embedded under the barrel. The experiment allowed acting for 80 days, which the bed material converted into vermicompost and at end the vermicompost were collected.

Diver (1998) reported that there are two main methods producing vermicompost tea: the method of fermentation (without aeration) and the method along with aeration. Through present experiment, vermicompost tea was produced by the method along with aeration. The ratio between water and vermicompost is important. With too much water, nutrients concentration reduces in whole solution and with too much compost, a large amount of nutrients available to the microorganisms and due to lack of oxygen, anaerobic conditions arise. Many studies have used the method of Weltzien (1991) with ratios of 1:3–1:10. Considering the mentioned matters, vermicompost tea was produced providing a 1:10 volumetric ratio of each vermicompost type and distilled water under aeration conditions provided by aquarium pomp. Samples were kept for 24 h at the temperature of 25 °C and then filtering process was performed by use of a jaconet cloth (Brinton and Droffner 1995).

Chemical and biological analysis

Numbers of earthworms in vermicompost obtained from three different organic beds were separated by light separation and hand sorting method through whole bed and then weighed. The cocoons were sorted manually.

To determine the properties of organic beds, vermicompost and vermicompost extracts were used from standard methods. Liquid organic fertilizers were poured into a crucible and placed in an oven (Gallenkamp Model OV-440, England) at 70 °C. After that, the condensed materials were ashed in a heavy-duty muffle furnace (Thermolyne Thermo Scientific FA1740-1, USA) at 350 °C (EPA 2004). Total nitrogen by the method of Micro-Kjeldahl (Bremner and Mulvaney 1982), total potassium using flame photometer (Page et al. 1982) and total phosphorous by molybdate vanadate yellow method (Chapman and Pratt 1961) were estimated. Concentrations of Fe, Zn, Cu and Mn by the method of dry ashing and digesting in HCl 2M, and finally were determined via using atomic absorption spectrometry model AA-670G method (Chapman and Pratt 1961). Organic matter was estimated by the method of oxidation with chromic acid then titration with ferrous ammonium sulfate (Nelson and Sommers 1982). A 1:5 ratio of water to vermicompost suspension was used to determine pH (Thomas 1996) and electrical conductivity (Rhoades 1996) of vermicompost, however, for vermiwash and vermicompost tea the mentioned parameters were determined without diluting.

Statistical analysis

Comparison of vermicomposts obtained from three different organic beds was conducted in a completely randomized design with three organic beds (leaf meal, cow manure and a combination of cow manure and leaf meal (1:1 w/w)) and three replications. Comparison of vermiwash and vermicompost tea obtained from types of vermicompost was conducted with a factorial arrangement in a completely randomized design with three replications and three factors: two levels of leaf meal vermicompost (vermiwash and vermicompost tea of leaf meal vermicompost), two levels of cow manure vermicompost (vermiwash and vermicompost tea of cow manure vermicompost) and two levels of combination of cow manure and leaf meal vermicompost (vermiwash and vermicompost tea of combination of cow manure and leaf meal vermicompost). Data analysis was performed by use of SAS 9.1 statistical program ANOVA. Means were compared by Duncan's Multiple Range Test (DMRT) using SAS statistical software.

Results and discussion

Worm growth and reproduction

The results indicated that maximum worms number (87.6 No./per bed) was recorded in the vermicompost produced from cow manure bed and the minimum (52.6 No./per bed) was observed in vermicompost produced from leaf meal. Also maximum (44.3 g/per bed) and minimum (26.4 g/per bed) weight of worms were related to the treatments of cow manure and leaf meal, respectively, which had a significant difference with other treatments. There was no significant difference between cocoons number in different beds (Table 2).

The results of this research are in accordance with the results of Warman and Anglopez (2010) who investigated the effect of different types of feedstocks including kitchen paper waste, kitchen yard waste, cattle manure yard waste on the worm weight and concluded that worm weight in this feedstock was different and related to type of feedstock and durations of vermicomposting. Studies showed that the kind, palatability and quality of food (in term of their chemistry) directly affected the survival growth rate and reproduction potential of earthworms (Suthar 2010b; Deka et al. 2011). In this study, the drastic variation in worm number and weight in vermicompost types were probably related to palatability as well as chemical nature of the feeding stuff. It may be due to increased feed for earthworm which was evident from higher nutrient content in cow manure (Table 4).

Chemical properties of vermicomposts obtained from organic beds

Based on results the highest EC (3.44 dS/m) was in the vermicompost produced from cow manure and the lowest (1.53 dS/m) was in vermicompost produced from leaf meal (Table 3). A reason of high salinity in produced vermicomposts in comparison with primary bed (Table 1) can be because of decomposing bed during the worm processes of digest and excretion of worm which increased the concentration of available ions toward the primary bed (John Paul et al. 2011). This result is well supported by the results of the previous works with different earthworm species during vermicomposting (Karmegam and Daniel 2009; Raja Sekar and Karmegam 2009; Prakash and Karmegam 2010).

According to the results, the highest and lowest quantity of pH which were 7.26 and 7.06 in the vermicompost produced from leaf meal and cow manure, respectively (Table 3). It was observed that pH was reduced during the process of vermicomposting that is accordance with the results of John Paul et al. (2011). This reduction in pH value can be due to high concentration of CO_2 and organic acids produced by microorganisms and earthworm. Biotic converting of organic matter to different intermediate materials,

Table 2 Comparison of worm number and weight and cocoon number of vermicompost types obtained from organic beds

Types of vermicompost	Worms number (no./per bed)	Worms weight (g/per bed)	Cocoons number (no./per bed)
Leaf meal vermicompost	52.6c	26.4c	12.3a
Cow manure vermicompost	87.6a	44.3a	20.0a
Leaf meal:cow manure vermicompost	70.6b	35.8b	18.3a

For each parameter, values in columns followed by the different small letters are significantly different at 0.05 levels. The data shown are the means of three replicates

Table 3 Comparison of OM, OC, pH, EC and C/N of vermicompost types obtained from organic beds

Types of vermicompost	OM (%)	OC (%)	pH	EC (dS/m)	C/N
Leaf meal vermicompost	35.6c	20.6c	7.26c	1.53c	13.0b
Cow manure vermicompost	59.9a	34.7a	7.06a	3.44a	12.5c
Leaf meal:cow manure vermicompost	50.9b	29.5b	7.11b	1.98b	14.6a

For each parameter, values in columns followed by the different small letters are significantly different at 0.05 levels. The data shown are the means of three replicates

Table 4 Comparison of nutrients concentration of vermicompost types obtained from organic beds

Types of vermicompost	N (%)	P (mg/kg)	K (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Leaf meal vermicompost	1.58c	1775c	1769c	515c	4.15c	45.8c	99c
Cow manure vermicompost	2.78a	2796a	3195a	1286a	9.46a	85.6a	145a
Leaf meal:cow manure vermicompost	2.2b	2552b	2789b	1097a	7.08b	69.4b	126b

For each parameter, values in columns followed by the different small letters are significantly different at 0.05 levels. The data shown are the means of three replicates intensive mineralization of organic nitrogen to nitrate and nitrite and phosphorous to ortho-phosphates can be considered as other reasons of pH reduction (Gunadi et al. 2002). Considering to what were mentioned, pH reduction in the bed of cow manure was more than other beds because cow manure was richer than other beds (Table 1) and worms activity and number were more in this treatment (Table 2).

Loh et al. (2005) investigated the effect of two beds of cattle and goat manure on pH changes in the vermicompost produced from them, they resulted that pH changed from neutral and alkaline values in beds to acidic values in the provided vermicompost. The same results obtained by Garg and Kaushik (2005). Hartenstein (1981) stated that pH reduction is an important factor for maintenance of nitrogen, because this important nutrient volatilize in the form of ammoniac gas at alkaline pH.

The results showed that, the highest values of organic matter and carbon were related to the vermicompost produced from cow manure which were 59.9 and 34.7%, respectively, and also the lowest values of them were measured in vermicompost produced from leaf meal which were 35.6 and 20.6%, respectively (Table 3). Also, the highest value of C/N ratio (14.6) was observed in vermicompost produced from combinational bed of cow manure and leaf meal and the lowest value of this ratio (12.5) was in the vermicompost produced from cow manure (Table 3). Richard (1976) reported that combination of manure with leaf meal leads to increase in C/N ratio.

All vermicomposts also showed reduction of C/N ratio than in the primary beds (Tables 1, 3). Because of the combined action of microorganisms and the earthworms, a large fraction of the organic matter in the primary beds is lost as CO_2 by the end of the vermicomposting period (Jayakumar et al. 2011). Govindan (1998) showed that the production of mucus and nitrogenous excrements enhanced the level of nitrogen in the vermicompost and it brought down the ratio of carbon to nitrogen which is most essential in the humification process. Also, the reduction of C/N ratio during vermicomposting is achieved by the combustion of carbon substrates during respiration.

Nutrients concentration of vermicomposts obtained from organic beds

Results indicated that vermicompost produced from cow manure significantly had more concentrations of Mn, Zn, Cu, Fe, K, P and N than two another beds (Table 4). The nutrient level of vermicompost depends on the nature of the organic material used as food source for earthworms (Garg et al. 2006; Suthar and Singh 2008). The higher percentage of nutrients level in vermicompost produced from cow manure in comparison with leaf meal may be attributed to the higher mineralization caused by earthworm action along with microorganisms and quality of primary beds (cow manure bed was richer than leaf meal bed). Amount of available nutrients increased through the vermicompost production process (Tables 1, 4). One reason for this result is the presence of carbon in the vermicompost for worms and microorganisms activity (Jayakumar et al. 2011). Losses in organic carbon might be responsible for N upgrading (Sangwan et al. 2008; Karmegam and Daniel 2009).

Increasing the level of P content during vermicomposting is may be due to mineralization of P due to phosphatases activity of microorganisms and earthworms (Krishnamoorthy 1990). The increased level of Zn and Fe in vermicompost indicated accelerated mineralization with selective feeding by earthworms on materials containing these elements. The increased level of nutrients in the vermicomposts was in accordance with the results of earlier works (Suthar 2007; Jayakumar et al. 2011).

Chemical properties of liquid organic fertilizers obtained from different vermicomposts

The results indicated that the highest values of OC and OM (12.22 and 21.06%, respectively) were in the vermicompost tea produced of cow manure vermicompost and the lowest values of them (0.60 and 1.04%, respectively) were measured in the vermiwash produced from leaf meal vermicompost. In each vermicompost type, vermicompost tea had significantly higher OC and OM than vermiwash. Also the highest value of pH was measured in the vermiwash produced from leaf meal vermicompost and the lowest value was observed through the vermicompost tea produced from cow manure. The highest (6.54) and lowest (1.35) amounts of the C/N ratio were observed through the vermicompost tea and vermiwash produced from leaf meal vermicompost, respectively. In general, in each vermicompost type the amount of C/N in vermicompost tea was significantly more than vermiwash (Table 5). At each vermicompost type, the value of pH in the produced vermiwash was significantly more than vermicompost tea. The highest value of EC (2.76 dS/m) was related to the vermicompost tea produced from cow manure vermicompost and the lowest value (1.52 dS/m) was observed in the vermiwash produced from leaf meal vermicompost. Greater concentrations of P, N, K, Mg, Na, Zn and Cu in vermicompost tea produced from vermicompost types, especially produced from cow manure vermicompost ("Nutrients concentration of liquid organic fertilizers obtained from different vermicomposts" section, Table 6) resulted in greater EC. The same results obtained by Pant et al. (2012). It was notable that the nature of the process vermicompost tea was found to have more effect on the chemical properties, as shown by significant differences between the characteristics of the two types of vermicomposted materials (leaf meal and cow manure). It is thought

Table 5 Comparison of OM, OC, pH, EC and C/N of liquid organic fertilizers (LOFs) obtained from vermicompost types

Types of vermicompost	LOFs	OM%	OC%	pH	EC (dS/m)	C/N
Leaf meal vermicompost	Vermicompost tea	14.85c	8.62c	7.24b	1.80cd	6.54a
	Vermiwash	1.04f	0.60e	7.56a	1.52d	1.35d
Cow manure vermicompost	Vermicompost tea	21.06a	12.22a	7.06c	2.76a	5.35b
	Vermiwash	3.38d	1.96d	7.52a	2.24b	2.37c
Leaf meal:cow manure vermicompost	Vermicompost tea	17.94b	10.41b	7.19bc	2.70a	6.14ab
	Vermiwash	2.05e	1.19de	7.54a	2.12bc	2.34c

For each parameter, values in columns followed by the different small letters are significantly different at 0.05 levels. The data shown are the means of three replicates

Table 6 Comparison of nutrients concentration of liquid organic fertilizers (LOFs) obtained from vermicompost types

Types of vermicompost	LOFs	N (%)	P (mg/l)	K (mg/l)	Fe (mg/l)	Cu (mg/l)	Zn (mg/l)	Mn (mg/l)
Leaf meal vermicompost	Vermicompost tea	1.32b	1118c	1703cd	7.57b	0.04b	13.30c	0.48b
	Vermiwash	0.45c	311d	820e	1.27c	Not detected	7.96c	Not detected
Cow manure vermicompost	Vermicompost tea	2.31a	1862a	2482.3a	12.07a	0.09a	25.56a	0.47b
	Vermiwash	0.83c	1677a	1907.3bc	3.09c	Not detected	8.76de	Not detected
Leaf meal:cow manure vermicompost	Vermicompost tea	1.71b	1377b	2104b	10.43ab	0.08a	19.93b	0.51a
	Vermiwash	0.51c	1004c	1655d	3.02c	Not detected	10.56d	Not detected

For each parameter, values in columns followed by the different small letters are significantly different at 0.05 levels. The data shown are the means of three replicates

that the superior biochemical and physical properties of vermicompost over thermophilic compost are reflected in tea quality (Edwards et al. 2006). These results are in accordance with the results of Pant et al. (2012) that reported either vermicompost or thermophilic compost can be used for the production of compost tea or vermicompost tea but the tea quality predicted based on compost or vermicompost quality. Carballo et al. (2009) stated that whole produced vermicompost tea cannot have the same quality and content.

Nutrients concentration of liquid organic fertilizers obtained from different vermicomposts

The results indicated that the total concentration maximum of N, P, K (2.31%, 1862.32 and 2482.3 mg/l, respectively) were in the vermicompost tea produced from cow manure vermicompost and the lowest values of these nutrients were measured in the vermiwash produced from leaf meal vermicompost (0.45%, 311 and 820 mg/l, respectively). There was no significant difference between N percent in the vermiwash produced from three types of vermicompost. P concentration in vermicompost tea produced from leaf meal vermicompost and combination of cow manure and leaf meal vermicompost was significantly more than their vermiwash, while there was no significant difference between P concentration in the vermicompost tea and vermiwash produced from cow manure vermicompost. K concentration in the vermicompost tea produced from three types of vermicompost was significantly more than vermiwash produced from them. The highest values of Cu, Zn and Fe (0.09, 25.56 and 12.07 mg/l, respectively) were in vermicompost tea produced from cow manure vermicompost, but the lowest values of Fe and Zn (1.27 and 7.96 mg/l, respectively) were in the vermiwash produced from leaf meal vermicompost. The maximum of Mn concentration was 0.51 mg/l which was observed in vermicompost tea produced from combination of cow manure and leaf meal vermicompost (Table 6). Results showed that vermicompost which was richer in nutrient concentrations (Table 4) affected intensively the quality of vermiwash and vermicompost tea produced from it. Pant et al. (2012) reported that higher mineral concentrations in compost explain greater concentrations of those nutrients in its tea. Positive correlations between mineral nutrient concentrations of compost and compost tea also explain the greater concentration of those nutrients in chicken manure-based thermophilic compost tea compared to the other teas.

We suspect that the design of the vermiwash beds may have remaining nutrients directly into the bedding material compared with vermicompost tea. Hargreaves et al. (2008) stated that vermicompost tea is more effective for enhancing plant growth conditions because of being richer in plant required macro and micro nutrients. Also N, P, K and many of micronutrients are considered as the main nutrients of vermiwash (Shivsubramanian and Ganeshkumar 2004).

Almost, the behaviors of the nutrients especially N for different vermicomposts and their tea products were similar. It may be due to the method used for vermicompost tea preparation and analysis (See the method section). The drying process may increase the concentrations of different nutrients due to condensation. Also, during the tea preparation, microbial population and activities, especially nitrogen-fixing microorganisms and N containing compounds may be increased. The decline in organic carbon (Tables 3, 5) might be responsible for N upgrading that was similar to the results of other researchers (Sangwan et al. 2008; Karmegam and Daniel 2009).

Conclusion

Vermicompost obtained from cow manure had more desirable effect on many measured traits toward leaf meal and combinational leaf meal and cow manure vermicomposts. Also vermicompost tea produced from all three vermicompost types was richer in terms of macro and micro nutrients, OM%, OC% and C/N toward the vermiwash produced from the same vermicompost. Vermiwash and vermicompost tea produced from cow manure vermicompost were at first order in majority of measured traits in comparison with others. Generally, the results showed that, qualities of vermiwash and vermicompost tea depend on type of beds and their vermicompost used.

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