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Evaluation of compost, vermicompost and their teas produced from rice straw as affected by addition of different supplements

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Abstract Ten treatments were prepared to find out the optimal combinations of different materials to be added to rice straw to produce high quality compost and vermicompost. The effect of addition of N, P and K either in organic or inorganic form as well as addition of bio-accelerator i.e. *Trichoderma harzianum* NRRL 13019 and *Phanerorchaete chrysosporium* NRRL 6359 were studied. Another set of the same 10 treatments was prepared by adding earthworm namely *Eisenia fetida* to each of the plastic bin which containing the pre-composted materials when the temperature steadily reached 30 °C i.e. after finishing the thermophilic phase. The composting process was continued in both sets up to 16 weeks. Tea was prepared using compost and vermicompost which were produced from the four best treatments.

Results revealed that the finished products of compost and vermicompost are free from total and fecal coliforms as well as *Salmonella* sp. and *Shigella* sp. The values of tested parameters of compost and vermicompost that produced from rice straw supplemented with cattle dung, organic P and K and fungal accelerator (treatment No. 7) were within the recommended levels of high quality products.

Introduction

Egypt is a highly successful producer of rice with average yield of more than 6.5 t ha^{-1} in 2011/12. Harvesting index of Egyptian rice varieties left up to 60% straw (FAO Rice Market Monitor, 2013). The options for disposal of straw on-farm are limited and include burning as a means of quickly

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cleaning land for the following crops. The burning causes atmospheric pollution. In addition, incorporation of rice paddy straw stubble into wet soil makes a temporary immobilization of N and methane (CH_4) emission that contributes to greenhouse gases (Dobermann and Fairhurst, 2002). Therefore, the most common practices for recycling rice straw and most of organic wastes are composting and vermicomposting (vermiculture) processes (Ghosh, 2004). Since composting and vermicomposting are of the most promising low-cost technologies to convert agro-industrial contaminant solid wastes into value-added biofertilizer (Misra et al., 2003).

There are many factors influencing the quality of produced compost, which include the pre-processing, particle size and feedstock utilized, the C/N ratio, bio-accelerator, nutrients amendment, pH, aeration, moisture content, temperature, the maturation stage, etc. (Last, 2006).

Vermicomposting is a low cost technology system used for conversion of organic waste into organic fertilizers (Arancon et al., 2004), at which several interactions between earthworms and microorganisms occur in the worm gut (Edwards, 1998). Earthworms can consume practically all kinds of organic matter typically that placed in a compost pile, and they can eat wastes typically equal to their own body's weight per day. The castings are rich in nitrate, phosphorus, potassium, calcium and magnesium (Misra et al., 2003).

Compost and vermicompost teas are made in a variety of ways; all methods are similar in having water and mature compost or vermicompost, to get their extract. There are different factors affecting the quality of compost tea and vermicompost tea, e.g. compost stability, the quality of water used in producing compost tea, brew time and aeration, additives (Ingham, 2005).

The objective of this investigation is to study the effect of addition of different supplements to rice straw on the general properties of mature compost, vermicompost and their teas.

Table 1 Chemical and physical characteristics of rice straw and cattle dung.

Characteristics	Rice straw	Cattle dung
pH (1:10)	6.56	7.35
EC (1:10) (dS/m)	2.63	4.40
Bulk density (kg/m^3)	50.00	750.00
Moisture content (%)	10.00	60.00
Dry matter (%)	90.00	40.00
Organic matter (OM %)	99.50	43.10
Organic carbon (OC %)	57.71	25.00
Total nitrogen (TN %)	0.50	2.00
NH_4^+-N (mg/kg)	17.50	43.74
NO_3^--N (mg/kg)	8.75	11.67
C/N ratio	115.4:1	21.5:1
Ash (%)	0.50	56.90
Total phosphorus (%)	0.36	0.65
Total potassium (%)	0.89	0.45

Table 2 Chemical and physical characteristics of rock phosphate and feldspar.

Characteristics	Rock phosphate	Feldspar
pH (1:2.5)	7.49	8.50
EC (1:5) (dS/m)	2.61	0.53
Moisture content (%)	3.00	0.95
Dry matter (%)	97.00	99.05
Total nitrogen (TN %)	0.015	0.025
Total phosphorus (%)	11.20	0.01
Total potassium (%)	0.55	11.62

Materials and methods

Rice straw was collected from Moshtohor, Qalubia Governorate, air dried and fragmented into small pieces (2–5 cm length). The chemical and physical properties of the collected rice straw are presented in Table 1. Analysis was performed by Microbiol. Dept., Soil, Water and Environmental, Res. Inst., A.R.C., Giza, Egypt.

Organic additives

Fresh cattle dung was collected from a private farm in Moshtohor, Qalubia Governorate. It was used as organic nitrogen source to adjust the C/N ratio of the rice straw. The chemical and physical properties of cattle dung are presented in Table 1. Analysis was performed by Microbiol. Dept., Soil, Water and Environmental Res. Inst., A.R.C., Giza, Egypt.

Rock phosphate (18% P_2O_5) was provided by Al-Ahram Company, Giza Governorate. It was used as a source of phosphorus. Feldspar (12% K_2O) was provided by Al-Ahram Company, Giza Governorate and used as a source of potassium. The general characteristics of the rock phosphate and Feldspar are presented in Table 2. Analysis was performed by Microbiol. Dept., Soil, Water and Environmental, Res. Inst., A.R.C., Giza, Egypt.

Inorganic additives

Ammonium sulfate (20.6% N); Super phosphate (12% P_2O_5) and Potassium sulfate (48% K_2O) were kindly provided by Soil, Water and Environmental. Res. Inst., A.R.C., Giza, Egypt.

Biological accelerators

Pure cultures of *Trichoderma harzianum* NRRL 13019 (as cellulose decomposer) and *Phanerochaete chrysosporium* NRRL 6359 (as lignin decomposer) were kindly provided by Microbiol. Dept., Soil, Water and Environmental Res. Inst., A.R.C., Giza, Egypt.

These cultures were used as compost activators in order to improve the quality of the compost. Each strain was grown individually in potato dextrose broth medium for 6–7 days in shaking incubator (150 rpm) at 28 °C.

Eisenia fetida used in this study was kindly provided by the Station of Using Earthworm Technology to Recycling of Organic Wastes Under Egyptian Conditions in the Central Laboratory for Agricultural Climate, Ministry of Agriculture and Land Reclamation, Agricultural Research Center, Egypt.

Experimental techniques

Ten treatments were prepared by thoroughly mixing the rice straw with different additives. Treatments were arranged in piles according to the components of each pile. The C/N ratio of the rice straw was adjusted to be 30:1 either by adding cattle dung in the treatments 7, 8, 9 and 10 or by adding ammonium sulfate in treatments 1, 3 and 5. Meanwhile, rice straw in treatments 2, 4 and 6 was left without adjusting the C/N ratio. The composting process was continued up to 16 weeks. Fungal inoculant was added to the pile at the rate of 5 L per ton of rice straw, before starting the composting process, as a biodegradable agent. The inoculant consists of dual cultures of each of *Trichoderma harzianum* NRRL 13019 (0.321 g.d.w/100 ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g.d.w/100 ml) at ratio 1:1.

The prepared ten treatments could be summarized as follows:

Treatment 1	Rice straw + ammonium sulfate + superphosphate + potassium sulfate
Treatment 2	Rice straw
Treatment 3	Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + ammonium sulfate + superphosphate + potassium sulfate.
Treatment 4	Rice straw + *T. harzianum* and *P. chrysosporium* 1:1
Treatment 5	Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + rock phosphate and feldspar 1:1 + ammonium sulfate
Treatment 6	Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + rock phosphate and feldspar 1:1
Treatment 7	Rice straw + cattle dung + *T. harzianum* and *P chrysosporium* 1:1 + rock phosphate and feldspar 1:1
Treatment 8	Rice straw + cattle dung + rock phosphate and feldspar 1:1
Treatment 9	Rice straw + cattle dung + *T. harzianum* and *P. chrysosporium* 1:1.
Treatment 10	Rice straw + cattle dung

Vermicompost preparation

The rice straw supplemented by different additives was aerobically decomposed either by native microorganisms or by both the native ones in conjunction with introducing fungal strains as bio-accelerators. When the thermophilic phase is finished, and the temperature reached 30 °C, *E. fetida* was introduced to each set of the plastic bin, containing the pre-composted material.

Preparation of compost tea and vermicompost tea

Preparation of tea was carried out using compost and vermicompost produced from treatments 1, 3, 7 and 8. Tea was prepared by soaking mature compost or vermicompost in tap water at ratio 8:1, then 50 ml sugarcane molasses and 100 ml yeast extract 10^5 cfu/ml were added and the mixture was aerated for 3 days using pump model SE-304, made in Germany, output: 2×2 OL/min and pressure: 0.01 MPa.

Physical and chemical determinations

The moisture % was calculated as a percentage for compost and vermicompost according to the method described by Page et al. (1982).

Bulk density (kg/m^3) was determined in compost and vermicompost using the core method according to Vomocil (1965).

The pH of compost, vermicompost, compost tea and vermicompost tea was determined in compost–water suspension (1:10) according to Jodice et al. (1982).

Electrical conductivity (EC) measurements were run in (1:10) compost and vermicompost water extracts according to the method described by Richards (1954).

Organic matter content was determined in compost and vermicompost materials as reported by Jackson (1973). While organic matter of compost tea and vermicompost tea were determined according to Black et al. (1965).

Total nitrogen, phosphorus and potassium were determined in compost, vermicompost, compost tea and vermicompost tea using the methods described by Jackson (1973).

NH_4^+ and NO_3^--N were determined in compost, vermicompost, compost tea and vermicompost tea according to the methods outlined by Page et al. (1982).

The Chemical Oxygen Demand (COD) in compost tea and vermicompost tea was determined using Walkley and Black method as described by Page et al. (1982).

The Biological Oxygen Demand (BOD) value was measured in compost tea and vermicompost tea according to the method described by Clair et al. (2003).

Statistical analysis

The obtain data were statically analyzed using Statistical Analysis System (SAS, 2006). Tukey's Multiple Range Test (HSD) was used to test significance between means at level 0.05 according to Snedecor and Cochran (1991). The general characteristics of mature compost and vermicompost were analyzed by one-way analysis of variance. While the data of compost tea and vermicompost tea were analyzed by two-way analysis of variance.

Results and discussion

General characteristics of mature compost as affected by addition of different supplements to rice straw

Data presented in Table 3 show that C/N ratio of the tested treatments could be categorized into two groups. The first group includes the treatments 2, 4 and 6 where the C/N ratio of these treatments in the finished product were too high when compared to the recommended range for good compost as reported by Cabanas-Vargas and Stentiford (2003). These treatments are characterized by the absence of nitrogen source, either in inorganic (ammonium sulfate) or organic (cattle dung) forms. The second group included the treatments 1, 3, 5, 7, 8, 9 and 10, all of them received nitrogen source either inorganic (ammonium sulfate) or organic form (cattle dung). The C/N ratio of these treatments is in the recommended range of good compost, being 21.3, 20.6, 21.1, 17.0, 17.2, 17.0 and

Table 3 Properties of mature compost as affected by different treatments of rice straw.

Treatments	Tested parameters													
	C/Nratio	Bulk density (kg/m^3)	Soluble N (mg/kg)		Total N (%)	Organic matter (%)	Ash (%)	Organic carbon (%)	PH (1:10)	EC (1:10) ($dS\ m^{-1}$)	Total phosphorus (%)	Total potassium (%)	Moist. (%)	Dry matter (%)
			NH_4^+	NO_3^-										
Rice straw														
[b]With inorganic amendments of P and K (Treatment 1)	21.3	203	203.3	606	2.4	88.2	11.8	51.2	8.2	5.67	1.66	1.77	50.2	49.8
Without inorganic amendments of P and K (Treatment 2)	66	190.3	8.8	105.8	0.82	93	7	53.9	7.2	3.43	0.78	1.24	46.7	53.3
Rice straw supplemented with fungal inoculants[a]														
[b]With inorganic amendments of P and K (Treatment 3)	20.6	278	157	712.3	2.42	86	14	49.9	8.2	5.53	1.67	1.79	50.4	49.6
Without inorganic amendments of P and K (Treatment 4)	50.6	197.3	39.2	354.7	1.04	90.8	9.2	52.7	7.7	3.87	0.74	1.32	49.7	50.3
Rice straw supplemented with fungal inoculants[a] + *organic amendments of P and K*[c]														
[d]With ammonium sulfate (Treatment 5)	21.1	261	144.7	660	2.39	87	13	50.5	8.3	5.62	1.41	1.56	51	49
Without ammonium sulfate (Treatment 6)	44	240.3	26	323.6	1.2	91	9	52.8	7.7	4.13	1.33	1.44	51.7	48.3
Rice straw supplemented with cattle dung[d] + *organic amendments of P and K*[b]														
[a]With fungal inoculants (Treatment 7)	17	639	42.5	449.2	1.69	49.6	50.4	28.8	8.3	5.14	1.5	1.73	52.9	47.1
Without fungal inoculants (Treatment 8)	17.2	620	50.3	426.3	1.53	45.5	54.5	26.4	8.3	5.1	1.49	1.58	49.5	50.5
Rice straw supplemented with cattle dung[d]														
[a]With fungal inoculants (Treatment 9)	17	631.7	56.2	457	1.5	44	56	25.5	8.3	4.78	1.14	1.43	57.2	42.8
Without fungal inoculants (Treatment 10)	18.1	608	45.9	309.7	1.41	43.9	56.1	25.5	8.4	4.33	1.13	1.24	51.7	48.3
HSD at 0.05	11.429	101.32	15.098	72.738	0.896	6.6086	6.4809	4.4304	1.277	1.6268	0.3622	0.4707	15.171	15.17

[a] 5 L from each *Trichoderma harzianum* NRRL 13019 (0.321 g.d.w/100 ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g.d.w/100 ml) at rat 1:1/ton rice straw.
[b] Inorganic amendments of P and K/ton rice straw; 3 kg super phosphate (12% P_2O_5); 15 kg potassium sulfate (48% K_2O).
[c] Organic amendments of P and K/ton rice straw; 25 kg rock phosphate (18% P_2O_5); 25 kg feldspar (12% K_2O).
[d] 2 Ton cattle dung (2% N)/ton rice straw.

18.1 respectively. The treatments 7 and 9 showed the best C/N ratio as compared to the others, being 17.0.

According to the bulk densities (kg/m^3), the treatments could be also divided into two groups. The first one includes treatments 1, 2, 3, 4, 5 and 6 all of them were free from addition of cattle dung. While the second group included the treatments 7, 8, 9, and 10, all of them were supplemented with cattle dung. The bulk densities values of the first group ranged from 90.3 to 278 kg/m^3, which are considered lower than the recommended range of good compost while, the values of the bulk densities in the second group ranged from 608 to 639 kg/m^3, which are considered in the recommended range of good compost as mentioned by Bordna Mona (2003).

Concerning ammoniacal nitrogen, results revealed that the highest significant concentration of NH_4 (mg/kg) was recorded in treatment (1), followed by treatment (3), being 203.3 and 157.0 mg/kg, respectively. These increments could be attributed to addition of ammonium sulfate to the raw materials at zero time. While treatment (2) showed the lowest concentration compared to all the tested treatments, being 8.8 mg/kg, since this treatment was prepared without any amendments to the rice straw.

The NO_3^--N concentration in the finished compost reached the highest significant value in treatment (3) followed by treatment (5), being 712.3 and 660 (mg/kg) respectively. These concentrations are considered as excessive nitrate nitrogen in the finished compost (Environment Agency, 2000) which could be attributed to nitrification process (Selim et al., 2012). While treatment (2) exerted the lowest concentration of NO_3^--N compared to the other treatments, being 105.8 mg/kg. The concentration of NO_3^- in treatments 4, 6, 7, 8, 9 and 10 is in the recommended range of good compost as reported by Bordna Mona (2003) and Selim et al. (2012).

The total nitrogen content, in all treatments, except treatment (2), is in the recommended range as stated by Sanchez-Monedero et al. (2001). The treatments 1, 3 and 5 recorded the highest significant nitrogen (%) compared to the other treatments, being 2.40%, 2.42% and 2.39% respectively. Such increases in total nitrogen (%) of these treatments could be attributed to addition of ammonium sulfate to the raw material to adjust the C/N ratio.

According to the organic matter values of the finished compost, the tested treatments could be categorized into two groups. The first one, comprised the treatments 1, 2, 3, 4, 5 and 6, which showed the highest significant values compared to the other treatments, being 88.2%, 93.0%, 86.0%, 90.8%, 78.0% and 91.0%. These concentrations are higher than the recommended range of the good compost. These results could be attributed to the reduction in the biodegradation rate of the raw materials during the composting process. The second group comprised the treatments 7, 8, 9 and 10 at which organic matter (%) is in the recommended range for good compost as stated by US Composting Council (2003), being 49.6%, 45.5%, 44% and 43.9%, indicating better biodegradation rate of the raw materials during the composting process.

In the view of the fact that organic carbon was calculated from organic matter, therefore, their values will be expected to show the same trend as organic matter values. The ash % of the mature compost in treatments 1, 2, 3, 4, 5, and 6 are lower than the threshold of good compost, being 11.8%, 7.0%, 14.0%, 9.2%, 13.0% and 9.0% while those recorded in the treatments 7, 8, 9, and 10 are in the recommended range, being 50.4%, 54.5%, 56.0% and 56.1% respectively.

The pH values of the finished compost of all treatments ranged from 7.2 to 8.4 which are in the recommended range of good compost as mentioned by Bordna Mona (2003). The EC values of the finished compost in all the tested treatments ranged from 3.43 to 5.67 $dS\,m^{-1}$ which fall within the recommended range of good compost (Bordna Mona, 2003).

The phosphorus (%) of the finished compost in treatments 1, 3, 5, 6, 7 and 8 were higher than the recommended range being 1.66%, 1.67%, 1.41%, 1.33%, 1.50%, and 1.49% respectively. While those in treatments 2, 4, 9 and 10 were found to be in the recommended range of good compost as reported by Bordna Mona (2003), being 0.78%, 74%, 1.14% and 1.13% respectively. The K (%) in treatments 1, 3 and 7 were higher than the threshold suggested by Bordna Mona (2003), being 1.77%, 1.79% and 1.73% respectively. While the K % in treatments 2, 4, 5, 6, 8, 9 and 10 are in the recommended range for good compost, being 1.24, 1.32, 1.56, 1.44, 1.58, 1.43 and 1.24 in respective order.

The moisture % in the final products of all the tested treatments are in the recommended range of good compost as stated by Biotreat, National Food Biotechnological Centre (2003), as it ranging from 46.7% to 57.2%.

The values of dry matter % of the finished compost are in the recommended range for the good compost, since they ranged from 42.8% to 53.3%. These results are in agreement with those reported by Biotreat, National Food Biotechnological Centre (2003).

General characteristics of mature vermicompost as affected by addition of different supplements to rice straw

As shown in Table 4, the C/N ratios of the mature vermicompost of the tested treatments ranged from 10 to 13.7. They are in the recommended range of good vermicompost as stated by Jordão et al. (2009) and Pandit et al. (2012). Hayawin et al. (2010) reported that the reduction in the C/N ratio to less than 20 reflects a satisfactory degree of maturity of organic waste. Hayawin et al. (2010) attributed the stability in the reduction of C/N ratio during vermicomposting process to the loss of carbon in the form of CO_2 through the respiration process as well as the production of nitrogenous excrements which increase the nitrogen level in the vermicast. The treatments 5 and 9 recorded the lowest C/N ratios, being 10:1 and 10.1:1 respectively. It was also noticed that both treatments participated in the presence of the cattle dung and fugal inoculants. Such interpretations are in the line with those reported by Kızılkaya et al. (2011), who stated that the addition of cattle dung or any organic wastes activate and accelerate the decomposition rate by earthworms.

The bulk densities of all the tested treatments ranged from 463.3 to 683.3 kg/m^3. The highest significant value was recorded with treatment (9), being 683.3 kg/m^3. While the lowest bulk density was recorded with the treatment (2), being 463.3 kg/m^3.

The NH_4^+-N contents of all the tested treatments, except treatment (2) are considered normal for good vermicompost, their values ranged from 21 to 50 mg/kg (Environment Agency, 2000). The mean values of NO_3 in all the tested treatments ranged from 158.2 to 210.9 mg/kg, which are in

Table 4 Properties of mature vermicompost produced by *Eisenia fetida* as affected by different treatments of rice straw.

Treatments	Tested parameters													
	C/N ratio	Bulk density (kg/m^3)	Soluble N (mg/kg)		Total N (%)	Organic matter (%)	Ash (%)	Organic carbon (%)	PH (1:10)	EC (1:10) ($dS\ m^{-1}$)	Total phosphorus (%)	Total potassium (%)	Moist. (%)	Dry matter (%)
			NH_4^+	NO_3^-										
Rice straw														
[b]With inorganic amendments of P and K (treatment 1)	11.8	516.7	37.3	196.4	1.66	33.9	66.1	19.6	8.1	1.54	2.6	2.28	34.4	65.6
Without inorganic amendments of P and K (treatment 2)	13.7	463.3	18.8	158.2	1.26	29.8	70.2	17.3	7.9	1.09	1.66	1.62	29.9	70.1
Rice straw supplemented with fungal inoculants[a]														
[b]With inorganic amendments of P and K (treatment 3)	11.2	572	40.37	191.9	1.88	36.4	63.6	21.1	8	2.37	2.81	2.48	44.4	55.6
Without inorganic amendments of P and K (treatment 4)	12.5	510.3	25.5	174.5	1.63	35.3	64.7	20.5	8	1.83	1.69	1.62	41	59
Rice straw supplemented with fungal inoculants[a] + *organic amendment of P and K*[c]														
[d]With ammonium sulfate (treatment 5)	10	650	40	194.9	1.76	30.2	69.8	17.5	7.9	1.65	1.83	1.73	35.2	64.8
Without ammonium sulfate (treatment 6)	13.3	524.7	27.8	164.5	1.44	33	67	19.1	8.3	1.57	1.81	1.69	43	57
Rice straw supplemented with cattle dung[d] + *organic amendments of P and K*[b]														
[a]With fungal inoculants (treatment 7)	10.4	636.7	31.7	210.9	1.88	33.8	66.2	19.6	7.9	2.56	2.05	2.01	38.7	61.3
Without fungal inoculants (treatment 8)	10.4	624.7	30.7	202.6	1.74	31.3	68.7	18.1	8	2.27	2	1.93	35.9	64.1
Rice straw supplemented with cattle dung[d]														
[a]With fungal inoculants (treatment 9)	10.1	683.3	34.42	200.3	1.81	31.5	68.5	18.3	8	2.11	1.72	1.63	40.2	59.8
Without fungal inoculants (treatment 10)	10.3	654.3	33.5	197.1	1.72	30.5	69.5	17.7	8	2.03	1.76	1.64	34.6	65.4
HSD at 0.05	3.174	110.94	11.526	97.422	0.4709	10.55	10.55	6.1336	1.4563	0.9845	1.0607	0.8282	11.033	11.033

[a] 5 L from each *Trichoderma harzianum* NRRL 13019 (0.321 g.d.w/100 ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g.d.w/100 ml) at rat 1:1/ton rice straw.
[b] Inorganic amendments of P and K/ton rice straw; 3 kg super phosphate (12% P_2O_5); 15 kg potassium sulfate (48% K_2O).
[c] Organic amendments of P and K/ton rice straw; 25 kg rock phosphate (18% P_2O_5); 25 kg feldspar (12% K_2O).
[d] 2 Ton cattle dung (2% N)/ton rice straw.

the recommended range of good vermicompost. Similar results were reported for vermicomposting of bio-solids, supplemented with cattle manure and oat straw (Contreras-Ramos et al., 2004). The total nitrogen of vermicompost in all the tested treatments ranged from 1.26% to 1.88% which are in the recommended range of good vermicompost as reported by Nogales et al. (2005). The treatments (3 and 7) recorded the highest significant increase, being 1.88% for both of them. While, treatment (2) recorded the lowest nitrogen %. These results are in agreement with those reported by Jordão et al. (2009).

The organic matter in the vermicompost of all the tested treatments ranged from 29.8% to 36.4%, as these values are lower than the recommended range reported for vermicompost by Jordão et al. (2009). The reduction in the organic matter content could be attributed to the rapid decomposition and consumption of the organic materials by earthworms and microorganisms present in their guts. The organic carbons % of all the tested treatments ranged from 17.3% to 21.1%. No significant differences were recorded between all of them.

The ash values of the tested treatments ranged from 63.6% to 70.2%. These values are in the recommended range of good vermicompost as reported by Pereira and Arruda (2003), while it was above the value as reported by Jordão et al. (2009).

The pH values of the vermicomposts ranged from 7.9 to 8.3 in all the tested treatments. These results are in the recommended range of good vermicompost as reported by Pandit et al. (2012). While other studies stated that the pH values of the final vermicompost could be ranged from alkaline to acidic (Garg et al., 2006).

The EC values of the finished vermicompost are in the recommended range of good vermicompost as reported by Ahmadabadi et al. (2011). The highest EC value was recorded with treatment (7), being 2.56 dS m^{-1}. While the lowest (1.09 dS m^{-1}) was recorded in treatment.

The total phosphorus and potassium (%) in the vermicompost of all the tested treatments were in the recommended range of the good vermicompost as reported by Pandit et al. (2012). They were higher in treatment (3), being 2.81% and 2.48% respectively, followed by treatment (1), being 2.60% and 2.28% respectively. While, the lowest concentrations of phosphorus and potassium were recorded in treatment (2), being 1.66% and 1.62% respectively.

The moisture % of the finished vermicomposts ranged from 29.9% to 44.4%. They are in the recommended range of good vermicompost as recorded by Jordão et al. (2009). On the contrary, these results are lower than the recommended range as reported by Ahmadabadi et al. (2011), who attributed the reduction of moisture % in the vermicompost to keeping the treatments without plastic cover during the vermicomposting process, which caused high evaporation rate.

Calculation of dry matter content is based on determination of the moisture contents; therefore their values are dependent on those of moisture content. The lowest dry matter was recorded with treatment (3), being 55.6%, while treatment (2) recorded the highest significant concentration of dry matter, being 70.1%.

Chemical and physical analyses of compost tea and vermicompost tea

This experiment was conducted to study the effect of the general characteristics of good compost and vermicompost on the quality of their teas to be used as biofertilizers. From the previous data it could be concluded that the treatments 1, 3, 7 and 8 exhibited approximately the best properties for compost and

Table 5 Properties of compost tea and vermicompost tea as affected by different treatments of rice straw.

Treatments	pH (1:10)	EC (1:10) (dS m^{-1})	BOD (ppm)	COD (ppm)	O.M (ppm)	NH_4^+ (ppm)	NO_3^- (ppm)	T.N (ppm)	T.P (ppm)	T.K (ppm)
Rice straw with fungal inoculants[a]										
Organic amendments[b] (treatment 7)										
Compost tea	7.97	2.11	115.00	4642.56	8004.24	4.37	24.76	742.56	11000.00	12000.00
Vermicompost tea	8.05	2.70	185.00	7320.96	12622.07	8.01	35.67	809.60	11200.00	13200.00
Inorganic amendments[c] (treatment 3)										
Compost tea	7.98	3.66	85.00	1428.48	2462.84	2.90	18.20	593.32	8200.00	9700.00
Vermicompost tea	8.00	2.40	110.00	4642.56	8004.24	10.20	33.46	600.04	11500.00	11900.00
Rice straw without fungal inoculants										
Organic amendments[b] (treatment 8)										
Compost tea	7.92	2.29	100.00	4106.88	7080.67	4.37	26.90	640.64	10500.00	11400.00
Vermicompost tea	8.02	2.94	125.00	4642.56	8004.24	11.65	20.38	776.84	12200.00	12700.00
Inorganic amendments[c] (treatment 1)										
Compost tea	8.00	3.15	50.00	1428.48	2462.84	7.28	19.67	312.31	8000.00	8400.00
Vermicompost tea	8.00	3.04	75.00	3749.76	6464.96	9.47	33.48	416.68	8600.00	9000.00
HSD at 0.05	1.53	1.17	21.41	420.46	1464.80	1.85	5.65	104.64	2661.20	1599.10

[a] 5 L from each *Trichoderma harzianum* NRRL 13019 (0.321 g.d.w/100 ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g.d.w/100 ml) at rat 1:1/ton rice straw.

[b] Organic amendments/ton rice straw; 2 ton cattle dung (2% N); 25 kg rock phosphate (18% P_2O_5); 25 kg feldspar (12% K_2O).

[c] Inorganic amendments/ton rice straw; 15 kg ammonium sulfate (20.6% N); 3 kg super phosphate (12% P_2O_5); 15 kg potassium sulfate (48% K_2O).

vermicompost, therefore the compost tea and vermicompost tea were prepared from these treatments.

Data recorded in Table 5 show that, pH values of all the tested treatments either vermicompost tea or compost tea ranged from 7.92 to 8.05. These data are in agreement with those reported by Scheuerell and Mahaffee (2004).

The EC values of all the tested treatments were found to be over the recommended range of good teas as reported by Pant et al. (2011).

It is worth to mention that the BOD values significantly increased in all the vermicompost teas compared to those recorded in the compost teas. Among the vermicompost and compost teas, treatment (7) exerted the highest significant BOD concentration, being 185 ppm. However, the compost tea prepared from treatment (1), recorded the lowest concentration, being 50 ppm.

The COD values of vermicompost teas were significantly higher compared to compost teas within the same treatments. The COD of vermicompost tea, prepared from treatment (7) exerted the highest concentration compared to all the teas either vermi or compost, being 7320.69 ppm. While the lowest value was recorded in the compost tea, prepared from treatments 3 and 1, being 1428.48 ppm for both.

The organic matter values in vermicompost teas were significantly higher compared to those of compost teas prepared from treatments 7, 3 and 1, while no significant difference was recorded between vermicompost and compost teas prepared from treatment (8). The organic matter reached its highest significant concentration in vermicompost tea of treatment (7), being 12622.07 ppm while the lowest value was recorded in the compost tea of treatments 3 and 1, being 2462.8 ppm for both.

Results presented in Table 5 also showed that the ammoniacal nitrogen concentrations of vermicompost and compost teas are in the recommended range of good teas as reported by Pandit et al. (2012). The ammoniacal nitrogen values were significantly higher in vermicompost tea compared to compost tea within the same treatments. The highest concentration of ammoniacal nitrogen was recorded with vermicompost tea of treatment (8), being 11.65 ppm. While the lowest value reached 2.9 ppm with compost tea of treatment (3). The nitrate concentrations, recorded in all the treatments, are in the recommended range of good teas as reported by Pandit et al. (2012). The nitrate nitrogen concentrations were significantly higher in vermicompost teas of treatments 7, 3 and 1 compared to compost tea of the same treatments. On the other hand, nitrate concentration in compost tea of treatment (8) was significantly higher compared to vermicompost tea prepared from the same treatment. NO_3^--N recorded its highest significant concentration in vermicompost tea prepared from treatment (7), being 35.67 ppm. While the lowest concentration was recorded with the compost tea prepared from treatment (3), being 18.2 ppm. However, the concentrations of total nitrogen in all the tested treatments are in the recommended range of good teas as reported by Siddiqui et al. (2009). Total nitrogen recorded its highest concentration with vermicompost tea of treatment (7), being 809.6 ppm, while the lowest one was recorded with compost tea of treatment (1), being 312.31 ppm.

The highest significant phosphorus concentration was recorded in vermicompost tea of treatment 8, being 12,200 ppm while the lowest concentration was recorded in compost tea of treatment 1, being 8000 ppm. The highest significant potassium concentration was recorded in vermicompost tea of treatment 7, being 13,200 ppm, while the lowest concentration was recorded with compost tea of treatment 1 being 8400 ppm. It should be stated that total phosphorus and total potassium in all the tested treatments are in the recommended range of good teas as reported by Siddiqui et al. (2009).

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