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Short Research Article

Effects of Different Organic Substrates on Quality of Vermicompost

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Abstract

The investigation was planned to work out the effect of various sources of organic matter such as animal dung, food waste, kitchen wastes, saw dust, parthenium, lantana, baggas, pine needle etc. on the quality of vermicompost. The organic carbon content in the vermicompost was decreased at greater extent at lower carbon: nitrogen ratio (30:1) compared to higher one. Other properties of vermicompost like nitrogen, organic carbon, ammonical nitrogen and nitrate nitrogen contents were also significantly higher in lower C:N ratio. The nutrient contents viz., Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur were found significantly higher under lower carbon nitrogen ratio of vermicompost. Use of pine needle as substrate was found inferior compared to all other substrates, whereas, boiled pine needle proved to be better option for vermicomposting. The quality of vermicompost prepared from Parthenium in combination with cow dung, baggas and kitchen waste was best compared to all other treatments. The use of boiled pine needle as substrate was found better compare to un-boiled one for better quality. Substrates of higher carbon: nitrogen ratio produced poor quality of vermicompost and also takes more time for decomposition, however, carbon: nitrogen ratio of 30 to 40 was found optimum for the process of vermicomposting.

1. Introduction

Organic manures play an important role in maintaining soil fertility and crop productivity. Use of organic manure is an age old practice of the farmers. During the past decades, organic manures were overlooked in comparison to chemical fertilizers that come with high yielding varieties of crop and high intensive crop rotation. In the recent years, increasing fertilizers input cost, soil health deterioration, sustainability and pollution consideration have led to renewed interest in the use of organic manures. In India a large amount, nearly 7000 million metric tons of organic materials such as farm waste and dairy wastes, is produced yearly (Bhaiday, 1994), which has large potential for production of organic manures, be it by composting and/vermicomposting.

Vermicompost provides excellent effect on overall plant growth, encourages the growth of new shoots leaves^{-1} and improves the quality and shelf life of the produce. It improves physico-chemical properties of soil and prevents soil erosion. Hand et al. (1988) define vermicomposting as a low cost technology system for the processing or treatment of organic wastes. In contrast to traditional microbial waste treatment, vermicomposting results in the bioconversion of the waste stream into two useful products i.e., the earthworm biomass and the vermicompost. The former product can further be processed into proteins (earthworm meal) or high-grade horticultural compost (Edwards and Niederer, 1988). The latter product (Vermicompost/castings) is also, considered an excellent product since it is homogenous, has desirable aesthetics, has reduced levels of contaminants and tends to hold more nutrients over a longer period, without adversely impacting the environment.

Vermicompost is a rich in beneficial micro flora such as N fixers, P solublizers, cellulose decomposing micro flora etc., in addition to improve soil environment. The role of organic carbon and inorganic nitrogen for cell synthesis, growth and metabolism in all living organisms, is critical. For proper nutrition, carbon and nitrogen must be present in the substrate at the correct ratio. An appropriate carbon to nitrogen ratio for optimal earthworm digestion is necessary too. The conventional determination of C-to-N ratio is usually based on the absolute contents of both the C and N in the substrate and of organic substrate quality is very important for vermicomposting as quality affects growth and reproduction of earthworm. Biomass of earthworm and cocoon production is directly related to the nature of substrate or bedding materials used for vermicomposting. Success cocoon hatchling and hatchling numbers per cocoon have close relation with quality of substrate. Depth of Substrate also affects the process of Vermicomposting and help for maintaining temperature during composting. Keeping this in view, the research trial was conducted to elucidate the influence of different organic substrates of variable C:N ratio on quality of vermicompost.

2. Materials and Methods

The experiment wascarried out at the experimental farm of the Department of Soil Science and Water Management, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). Soil is sandy loam in texture where maximum precipitation received during the months of July-Oct.

The experiment was comprised of eight treatments viz.,T_1 (Substrate 1, 30 C: N), T_2 (Substrate 2, 40 C: N), T_3 (Substrate 3, 50 C: N), T_4 (Substrate 4, 60 C: N), T_5 (Substrate 5, 70 C: N), T_6 (Substrate 6, Pine needles mix with other substrate so as to get C: N ratio of 50), T_7 (Substrate 7, Boiled pine needles with other substrate so as to get C: N ratio of 50) and T_8 (Substrate 8, Cow dung only) with four replications and the experimental design was RBD.The experiment conducted by using cement rings (collar) of 0.19 m^3 volumetric capacity (diameter: 110 cm× height : 20 cm) with exposed top surface area of 0.95 m^2 and an estimated quantity of water was sprinkled on the substrate to achieve a range of moisture content between 60-75% throughout the experimentation. All the rings were established on plastic sheet to avoid leaching losses of humus and nutrients etc., A suitable device (plastic containers of 5 litre capacity) below the plastic sheet was installed for the collection of leach ate. This leach ate was again sprinkled over for maintaining moisture content of substrate. After 15 days of monitoring the substrate, 300 g of earthworms (approx. 500 nos.) of species *Eisenia foetida* were released. The compost prepared was analyzed for their C:N ratio, ammonium and nitrate nitrogen contents at an interval of 1 month. However, complete analysis of compost as prepared at the end of experimentation after 4 months were done for their pH, EC, carbon content and total macro and micro nutrients and microbial activity etc.

The composition of different biomass taken for experimental details is presented in Table 1. A known quantity of all these biomass were saw dust, kitchen waste, pine needle, cattle dung, sugarcane trash, lantana and parthenium taken in different combinations according to their composition (Table 1) so as to obtain variable C: N ratio of about 30, 40, 50, 60 and 70. The different biomass like saw dust, kitchen waste, pine needle, cattle dung, sugarcane trash, lantana and parthenium were collected from university premises and local market at Solan for experimentation.

The entire C:N ratio of feed mixtures (substrates) was computed by using standard equation and prepared on the basis of previously determined absolute value of total organic carbon, total nitrogen and moisture present in each substrate as mention below:

$$R=\frac{Q_1\ldots n[C_1\ldots n\times(100-M_1\ldots n)]+Q_2\ldots n\,[C_2\ldots n\times(100-M_2\ldots n)]+\ldots}{Q_1\ldots n[N_1\ldots n\times(100-M_1\ldots n)]+Q_2\ldots n\,[N_2\ldots n\times(100-M_2\ldots n)]+\ldots}$$

Where; R=C: N ratio of mixture, $Q_{1\ldots n}$=mass of material n, $C_{1\ldots n}$=carbon (%) of material n, $N_{1\ldots n}$=nitrogen (%) of material n, $M_{1\ldots n}$=moisture content (%) of material n

The actual amount of different materials computed by the equation mention above is presented in Table 2. All these substrates were mixed as per treatment and obtained a homogeneous mixture. The homogeneous mixture as prepared was sampled and analyzed for their actual carbon and nitrogen contents and computation of its C:N ratio.

The samples after partial decomposition collected at 0^{th}, 30^{th} 60^{th}, 90^{th} and 120^{th} day from each treatment were spread on a sheet paper for air drying and were subsequently put in a paper bag, which were kept in hot air oven at 60±5 °C for 48 hours for drying. The dried samples were crushed, ground and stored in polythene bags for further chemical analysis.

Well ground samples of known weight were digested in di-acid mixture prepared by mixing concentrated HNO_3 and $HClO_4$ in the ratio of 4:1 observing all relevant precautions as laid down by Piper (1966) for the analysis of nutrients like P, K, Ca, Mg, S, Cu, Zn and Fe. Separate digestion for nitrogen estimation was carried out by using concentrated H_2SO_4 and digestion mixture (Potassium sulphate 400 parts, copper sulphate 20 parts, mercuric oxide 3 parts, selenium powder 1 part) as suggested by Jackson (1973). Nutrients were estimated following the methods given in Table 3.

3. Results and Discussion

In the present study, the effect of carbon:nitrogen ratio

Table 1: C:N ratio of different biomass

Substrate	Carbon (%)	Nitrogen (%)	C:N ratio
Saw dust	57. 07	0.56	101.91
Sugarcane trash (baggas)	56.14	0.56	100.25
Parthenium	56.02	1.12	50.02
Pine needle	56.02	0.56	100.05
Kitchen waste	43.38	2.24	19.36
Lantana	52.89	1.68	31.48
Cow dung	48.02	1.43	33.71

Table 2: Compositions of treatments

Treatments / Substrate (wt. in kgs.)	Sawdust	Sugarcane	Parthenium	Pine needle	Kitchen waste	Lantana	Cowdung	Total
T_1	-	5.00	4.67	-	8.50	-	3.86	21.00
T_2	7.41	8.96	-	-	-	3.51	8.00	27.88
T_3	8.36	6.39	_	1.18	_	_	4	19.93
T_4	10.64	1.78	_	4.6	_	_	3	20.02
T_5	17	4.73	2.43	_	_	_	3	27.16
T_6	12.29	2	_	8.77	_	_	6	29.06
T_7	12.29	2	_	8.77	_	_	6	29.06
T_8	_	_	_	_	_	_	20	20

Table 3: Chemical methods used for the analysis of vermicompost

Parameters	Methods and references
Organic carbon (OC)	Walkley and Black wet digestion method
N	Microkjeldahl method (Jackson, 1973)
P	Vanado-molybdate phosphoric yellow color method (Jackson, 1973)
K	Flame photometre method (Jackson, 1973)
Ammonium and Nitrate nitrogen	MgODeverda alloy method

on quality of vermicompost was evaluated on the basis of increase in nitrogen content of substrate (Table 4). The highest increase in total nitrogen content of the substrate was recorded in treatment T_1 (30, C: N) regardless of the period of composting process. Highest increase in nitrogen content was recorded at later period of composting process. Total nitrogen content ranged from 0.82 to 1.60, 1.14 to 1.73, 1.23 to 1.98, 1.26 to 2.12, and 1.26 to 2.27% at 0, 30, 60, 90 and 120 day of vermicomposting process with a mean value of 1.12, 1.39, 1.52, 1.62 and 1.72, respectively, with the highest value (2.27%) under T_1 and lowest (1.26%) under T_6 treatment at the end of experimentation. The interactive effect of different substrate and period of composting also found significant at all the stages of composting. Different C:N ratio of the substrate also significantly influenced process of composting and nitrogen contents. Lowest C:N ratio had highest nitrogen content (2.27%), and highest C:N ratio had lowest nitrogen content (1.54%). Total nitrogen content ranged from 1.60 to 2.27, 1.22 to 1.96, 1.02 to 1.69, 0.89 to 1.68, and 0.80 to 1.54 under 30, 40, 50, 60 and 70 C:N ratio with a mean value of 1.94, 1.62, 1.42, 1.36 and 1.28, respectively. The treatments (T_6 and T_7) in which pine needles was used as substrate found inferior compared to all other combinations, however, boiled pine needle (T_7) was found comparatively better than T_6. Substrate of higher C:N ratio take more time for composting and 30 to 40 C:N ratio was found optimum for vermicomposting. The treatment (T_8) in which only cow dung was used as substrate found equally good compare to treatment T_1 and T_2. Treatment (T_1) found best and statistically superior over all the treatments, where kitchen waste, parthenium and sugarcane trash was used as substrate. These observations were in accordance with the findings of Edwards (1995) who reported that *Eisenia foetida* helps to increase nitrogen content. The vermicompost produced after feeding the worms have increased nitrogen content. These findings were in agreement with the findings of Singh and Rai (1997); Vashanti and Kumarswamy (1999); Probodhini (1994).

Table 4: Changes in Nitrogen contentof bedding material at different intervals under vermicomposting

Treatment*	Nitrogen (%)					
	0	30	60	90	120	Mean
$T_{1(30)}$	1.60	1.73	1.98	2.12	2.27	1.94
$T_{2(40)}$	1.22	1.54	1.64	1.82	1.96	1.64
$T_{3(50)}$	1.02	1.41	1.41	1.55	1.69	1.42
$T_{4(60)}$	0.89	1.28	1.40	1.54	1.68	1.36
$T_{5(70)}$	0.80	1.22	1.40	1.42	1.54	1.28
$T_{6(50)}$	1.02	1.14	1.23	1.26	1.26	1.18
$T_{7(50)}$	1.03	1.28	1.43	1.58	1.59	1.38
$T_{8(33)}$	1.43	1.54	1.67	1.68	1.82	1.63
Mean	1.12	1.39	1.52	1.62	1.72	
CD	0.08	0.09	0.11	0.09	0.10	
Tr	0.04					
P	0.03					
T×P	0.09					

*Figures in parenthesis indicate C:N ratio of organic substrate

Theeffect of carbon: nitrogen ratio on quality of vermicompost was evaluated on the basis of decrease in organic carbon content of substrate (Table 5). The organic carbon content in vermicompost recorded on monthly interval at 0th, 30th, 60th, 90th and 120th days of composting process showed significant decrease with the passage of time in all the treatments. These observations were in accordance with the findings of Curry et al., 1995; Edwards and Bohlen 1996 who also reported that the reduction in carbon content during first 3-4 months of vermicomposting could be due to respiratory activity of earthworms and microorganisms. The organic carbon content was recorded at 0th day (47.68-56.36%), 30th day (27.52-52.86%), 60th day (21.91-52.24%), 90th day (21.12-51.24%) and 120th day (20.94- 50.57%) of vermicomposting process with mean value of 52.15, 46.09, 41.65, 40.48 and 40.10%, respectively. Highest decrease of organic carbon content was recorded at 120 days in T_8 (47.68-20.94%) and lowest in T_6 (51.85- 50.57%). The interactive effect of different substrate and period of composting was also found significant at all the stages of composting. The lowest decrease (52.95 to 50.57%) was recorded under treatments T_6 in which pine needles was used as substrate. However, boiled pine needle (T_7) was found comparatively superior over unboiled one (T_6) in response to decline in carbon content. Substrate of higher C:N ratio take more time for composting and 30 to 40 C:N ratio was found optimum for vermicomposting. Boiling of pine needle before using as substrate for vermicompostig showed significant effect on decline in organic carbon content compared to unboiled one. The use of only cow dung as substrae was used found best compare to all other combination.

The highest ammonical nitrogen content was recorded at later period of composting process. Total ammonical nitrogen content ranged from 110 to 239, 122 to 248, 127 to 260 and 136 to 273 ppm at 30th, 60th, 90th and 120th day of vermicomposting process with a mean value of 151, 170, 178 and 188 respectively, with the highest value (273 ppm) under T_8 and lowest (136 ppm) under T_6 treatment at the end of experimentation (Table 6). The interactive effect of different substrate and period of composting also found significant at all the stages of composting. Different C:N ratio of the substrate also significantly influenced process of composting and ammonical nitrogen contents. These observations were in accordance with the findings of Ruz et al., 1988; Scott et al., 1998 who also reported that earthworm increases the nitrogen content due to nitrogen mineralization from organic matter in the vermicompost because nitrification is enhanced in worm casts, the ratio of nitrate nitrogen to ammonium-nitrogen tends to increase when earthworms are present in the vermicompost.

It is revealed from the Table 7 that the highest increase in nitrate nitrogen content of the substrate was recorded in treatment T_1 (30, C:N) regardless of the period of composting process. Highest nitrate nitrogen content was recorded at later period of composting process. Total nitrate nitrogen content ranged from 66 to 156, 82 to 162, 83 to 178 and 122 to 192%

Table 5: Changes in Organic carbon content of different bedding material under vermicomposting

Treatment*	Organic carbon (%)					
	0	30	60	90	120	Mean
$T_{1(30)}$	51.81	41.16	36.69	34.19	33.38	39.44
$T_{2(40)}$	51.90	46.98	36.83	36.36	36.35	41.68
$T_{3(50)}$	52.06	48.23	39.95	39.01	38.95	43.64
$T_{4(60)}$	54.02	49.75	46.34	45.07	44.96	48.03
$T_{5(70)}$	56.36	52.86	52.24	51.24	50.57	52.65
$T_{6(50)}$	51.85	51.12	50.88	50.73	49.87	50.89
$T_{7(50)}$	51.53	51.10	48.36	46.10	45.83	48.58
$T_{8(33)}$	47.68	27.52	21.91	21.12	20.94	27.83
Mean	52.15	46.09	41.65	40.48	40.10	
CD	3.31	3.09	3.18	3.04	2.80	
Tr	1.33					
P	1.06					
T×P	2.98					

*Figures in parenthesis indicate C:N ratio of organic substrate

Table 6: Changes in ammonical nitrogen contents of bedding materials at different intervals under vermicomposting (ppm)

Treatment*	Ammonical nitrogen (ppm)				
	30	60	90	120	Mean
$T_{1(30)}$	165	224	242	251	221
$T_{2(40)}$	163	175	177	189	176
$T_{3(50)}$	144	165	167	185	165
$T_{4(60)}$	141	153	159	162	154
$T_{5(70)}$	134	141	148	150	143
$T_{6(50)}$	110	122	127	136	124
$T_{7(50)}$	116	135	140	153	136
$T_{8(33)}$	239	248	260	273	255
Mean	152	170	178	188	
CD	14	15	14	11	
Tr	7				
P	5				
T×P	13				

*Figures in parenthesis indicate C:N ratio of organic substrate at 30th, 60th, 90th and 120th day of vermicomposting process with a mean value of 124, 135, 143 and 162, respectively, with the highest value (192) under T_1 and lowest (122) under T_6 treatment. The interactive effect of different substrate and period of composting also found significant at all the stages of composting. Different C:N ratio of the substrate also significantly influenced process of composting and nitrogen contents. Lower C:N ratio had higher nitrate nitrogen content (192), higher C:N ratio had lower nitrate nitrogen content. Substrate of higher C:N ratio require more time for composting and 30 to 40 C:N ratio found optimum for vermicomposting. These findings were again supported by Ruz et al., 1988; Scott et al., 1998 who also reported that earthworm increases the nitrogen content due to nitrogen mineralization from organic matter in the vermicompost because nitrification is enhanced in worm casts, the ratio of nitrate nitrogen to ammonium-nitrogen tends to increase when earthworms are present in the vermicompost.

The effect of carbon: nitrogen ratio on quality of vermicompost was evaluated on the basis of increase in nutrient content of substrate (Table 8). The nutrient content in vermicompost recorded at the end of the experiment after 120 days of composting process. The maximum nitrogen content was recorded in T_1 (2.27%) which was statistically superior and minimum was recorded in T_7 (1.26%) at the end of the experiment. Lowest C:N ratio had highest nitrogen content (2.27%), and highest C:N ratio had lowest nitrogen content (1.26%). However, the maximum phosphorus content was recorded in T_8 (1.24%) which was statistically superior and minimum was recorded in T_6 (0.19%) at the end of the experiment. Lowest C:N ratio had highest potassium content (0.72%), and highest C:N ratio had lowest potassium content (0.20%). The treatments (T_6 and T_7) in which pine needles was used as substrate found inferior compared to all other combinations, however, boiled pine needle T_7 (0.23%) contain more potassium at the end of experiment as compared to T_6 (0.21%).

The maximum calcium content was recorded in T_8 (3.13%) which was statistically superior and minimum was recorded in T_6 (0.99%) at the end of the experiment. The treatments (T_6 and T_7) in which pine needles was used as substrate found inferior compared to all other combinations, however, boiled pine needle T_7 (1.81%) contain more calcium at the end of experiment as compared to T_6 (0.99%). However, boiled pine needle (T_7) was found comparatively superior over unboiled one (T_6) inresponse to decline in carbon content. Substrate of higher C: N ratio take more time for composting and 30 to 40 C: N ratio was found optimum for vermicomposting. However, the maximum magnesium content was recorded in T_1 (0.34%) which was statistically superior and minimum was recorded in T_6 (0.13%) at the end of the experiment. Lowest C:N ratio had highest magnesium content (0.34%), and highest C:N ratio had lowest magnesium content (0.13%). The maximum sulphur content was also recorded in T_1 (0.50%) which was statistically superior and minimum was recorded in T_5 (0.20%) at the end of the experiment.

Table 7: Changes in nitrate nitrogen contents of bedding materials at different intervals under vermicomposting (ppm)

Treatment*	Nitrate Nitrogen (ppm)				
	30	60	90	120	Mean
$T_{1(30)}$	152	162	173	192	170
$T_{2(40)}$	156	161	167	167	162
$T_{3(50)}$	141	146	149	163	150
$T_{4(60)}$	123	134	135	159	138
$T_{5(70)}$	119	121	124	150	128
$T_{6(50)}$	66	82	83	122	88
$T_{7(50)}$	83	112	136	162	123
$T_{8(33)}$	150	160	178	180	167
Mean	124	135	143	162	
CD	12	15	16	13	
Tr	7				
P	5				
T×P	14				

*Figures in parenthesis indicate C:N ratio of organic substrate

Table 8: Nutrient content of vermicompost at the end of experiment (%)

Treatment*	Nitrate Nitrogen (ppm)					
	N	P	K	Ca	Mg	S
$T_{1(30)}$	2.27	0.60	0.57	2.75	0.34	0.50
$T_{2(40)}$	1.96	0.45	0.48	2.19	0.19	0.32
$T_{3(50)}$	1.69	0.36	0.28	2.59	0.20	0.24
$T_{4(60)}$	1.68	0.28	0.20	1.98	0.23	0.37
$T_{5(70)}$	1.54	0.23	0.32	1.57	0.25	0.20
$T_{6(50)}$	1.26	0.19	0.21	0.99	0.13	0.23
$T_{7(50)}$	1.59	0.20	0.23	1.81	0.17	0.27
$T_{8(33)}$	1.82	1.24	0.72	3.13	0.31	0.44
CD	0.10	0.05	0.03	0.12	0.01	0.02

*Figures in parenthesis indicate C:N ratio of organic substrate

These observations were in accordance with the findings of Edwards (1995) who also reported that *Eisenia foetida* helps to increase the microbial activity and release the nitrogen, potassium, magnesium and calcium. Jambhekar (1992) also reported higher content of NPK and micronutrients in vermicompost. The vermicompost produced after feeding the worms have increased nitrogen, phosphorus and potassium.

4. Conclusion

The vermicompost prepared from *Parthenium* in combination with cow dung, bag gas and kitchen waste which initially had a C:N ratio of 32.23 reduced to 12.66 at the end of experiment and found best for vermicomposting compare to all other resources. Use of only cow dung as a substrate was also equally good option for vermicomposting. The use of boiled pine needle as substrate was found better compare to un-boiled one. Substrates of higher carbon: nitrogen ratio produced poor quality of vermicompost and also takes more time for decomposition, however, carbon: nitrogen ratio of 30 to 40 was found optimum for the process of vermicomposting.

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