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Composting of Organic Residues as Influenced by Effective Microorganisms and Earthworms

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A study was undertaken at central experimental station, Wakawali, Maharashtra to evaluate the influence of effective microorganisms and earthwarms on compositing of organic residues. There was a decrease in C:N ratio of all the residues during composting. The C:N ratio was brought down below 15 in all the treatments on 150th day of composting. The maximum reduction in C:N ratio was observed in Shivan leaves (68.95%) followed by Ain leaves (66.56%). Inoculation of *Eudrilus eugineae* resulted in significantly decrease in C:N ration than *Eisenia foetida*. Composting of organic residues with earthworms and EM solution resulted in significant increase in cation exchange capacity {86.83 c mol (p^+) kg^{-1}}. Inoculation of *E. eugineae* was found to be superior as compared to *E. foetida* in increasing CEC {84.83 C mol (P^+) kg ha^{-1}}. There was increase in humic acid and fulvic acid content of all the four crop residues under study. Humification of residues was better with *E. eugineae* than *E. foetida*. Inoculation of *E. foetida* significantly increased the fulvic content

(***Key words*** : *Composting, Earthworm, Effective microorganism, Organic residues*)

The utilization of organic waste material through agency of earthworm has assumed significance because the technology of vermicomposting is simple, economical and environment friendly. The key role of earthworms in improving soil fertility has been known since the dawn of agriculture, but its potential contribution towards agricultural production and pollution control has been receiving attention recently. (Kale and Krishnamoorthy, 1981). With capability of breaking, grinding, churning and assimilation, earthworms have proved to be marvelous converter of wastes.

India is a rural country and has vast potential of manurial resources, such as animal waste, crop residues, green manures, marine and agro-industrial wastes. Among these sources crop residues have been receiving a considerable importance. Plant residues such as local grass, dried leaves of mango, cashew, ain, shivan, jackfruit, teak etc. and farm wastes like straw and stubbles of rice, ragi, groundnut, cowpea etc. are available in ample quantity in Konkan region.

The conventional method of composting takes a long time of about 6-8 months to produce compost from these residues. The compost prepared from these residues is poor in nutrient content and bulky in nature. Therefore, these wastes can be effectively recycled in the form of good quality manure through vermicomposting coupled with the use of effective microrganisms which will reduce the composting period and increase the nutrient status of compost. Hence the present investigation was undertaken to study the decomposition of crop residues through vermicomposting and use of effective microorganisms.

MATERIAL AND METHODS

The present study was conducted at Central Experiment Station, Wakawali during 2008-09 in Factorial Randomized Design with two factors where factor I was substrate comprising of four levels i.e. mango, cashew, shivan and ain leaves and Factor II comprised of two species of earthworms viz. *Eisenia foetida* and *Eudrilus eugineae*. There were 8 treatment combinations replicated thrice. The vermicomposting of the organic residues were carried out in cement tanks under shade having dimensions 2 m x 1 m x 1 m. A 15 cm layer of decomposed cow dung was spread at the bottom of tank and 15 cm layer of partially decomposed leaves was spread over this top of the partially decomposed cow dung layer. This was watered regularly to maintain moisture level at 50 per cent. About 200 earthworms of the *Eisenia foetida* and *Eudrilus eugineae* species were introduced as an optimum inoculating density in the vermibed of each tank. This layer served as vermibed i.e. temporary habitat for earthworms. The effective microorganisms (EM) are being used with great success

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as an innoculant for composting a wide variety of organic wastes. A 20 ml EM solution was diluted to 1 liter water and spread uniformly in each tank. The EM available in liquid form contains strains of P-solubilizing bacteria, lactic acid bacteria, actinomycetes, N fixing bacteria, cellulose degrading bacterial and yeast (cfu $1x10^8$). The material from each tank was turned over manually at an interval of one month. The maturity of the compost was adjudged by following to procedure given by Sarangi and Lama (2013). The samples were collected at 150th day with the help of soil tube auger from top to bottom and were analyzed for various properties by following standard procedures.

RESULTS AND DISCUSSIONS

Changes in C:N ratio

It was revealed that the differences in C:N ratio of all four residues varied significantly right from the commencement of composting upto the 150^{th} day of composting. Initially maximum C:N ratio was observed in shivan leaves (46:35) and it was significantly superior over all the other materials used. The maximum C:N ratio (31.68) was observed in cashew leaves and it was at par with mango leaves (33.69). The C:N ratio of cashew leaves was significantly lower than Shivan and Ain leaves. There was a drastic reduction in C:N ratio of all the residues on 150th day and minimum C:N ratio was noted in mango leaves. The trend of decrease in C:N ratio was of the order SL>CL>AL>ML> on 150th day. This may be attributed to enhanced microbial activity, as carbon is utilized by microorganisms for their energy requirement and cause transformation of soluble nitrogen to microbial protein thereby preventing nitrogen loss. Sharma *et al.,* (2004) showed that efficient recycling of used plants and congress grass through vermicomposting substantially reduced the C:N ratio to 14.5:1 in lantana and 17.4:1 in congress grass. Singh *et.al*. (2006) and Sitaramalakshmi *et. al.* (2013) also observed a decrease in C:N ratio of various organic residues.

As regards the effect of earthworms on C:N ratio is concerned, it was observed that, C:N ratio was not affected significantly due to two species of the earthworms on 150th day of composting. There was a drastic decrease in C:N ratio on 150th day as compared to initial. This may be because; earthworms utilize the organic matter as food and release part of carbon as CO_2 in the process of respiration. The production of mucous and nitrogenous excrements enhance the level of nitrogen and this in turn leads to lowering of C:N ratio. These results are in conformity with those obtained by Manna *et. al*. (1999), Gajbhiye and Satpute (2014).

The interaction of various crop residues and earthworm on the changes in C:N ratio was found to be significant on 150th day of composting. The minimum C:N ratio was observed in treatment T_2 (13.00) where cashew leaves were inoculated with *E foetida* and was significantly different from T_6 (15.76) where *E. eugineae* were inoculated with cashew leaves and at par with all the remaining treatments. Inoculation of earthworms to al the residues resulted in reduction in C:N ratio. The C:N ratio was less than 15 in almost all treatments except T_6, (CL+EE). The maximum reduction in C:N ratio was noted in shivan (14.39) irrespective of treatments. This might be due to more degradable constituents as compared to other substrates. Mann *et al.* (1997) reported that the inoculation of organic wastes with bi-inoculants lowered the initial organic carbon and increased total nitrogen, consequently decreasing the C:N ratio. The results are conformity with those reported by Gajbhiye and Satpute (2014), Padmadevi *et al.* (2012).

Cation exchange capacity

The perusal of data from Table 2 revealed that the differences in CEC of decomposing organic residues were statistically found to be significant. Initially maximum CEC of 37.83 c mol (p^+) kg^{-1} was recorded in Ain leaves followed by shivan leaves (37.42), mango leaves (35.42) and cashew leaves (28.67). The trend of increase in CEC was of the order SL>ML>AL>CL. Finally on 150th day CEC reached upto 86.83 c mol(p^+) kg^{-1} in shivan, 85.37 c mol (p^+) kg^{-1} in ain leaves and 69.50 c mol (p^+) kg^{-1} in cashew leaves.

The effect of earthworm inoculation on increase in cation exchange capacity was found to be statistically significant on 150th day of compost sampling. Inoculation of *E. enegiueae* resulted in significant increase in CEC over *E. foetida*. Albanell *et al.* (1988) studied the changes during vermicomposting of sheep manure mixed with cotton industrial waste and reported that there was increase in CEC from 35.5 to 79.6 c mol (p^+) kg^{-1}. Manna *et al*. (1994) studied the changes in CEC of various organic residues inoculated with vermiculture after 180 days of composting. The results indicated that inoculation of material with earthworms significantly increased the CEC of all the waste materials but increase in CEC of inoculated material was relatively less as compared to control.

Table 1. *Changes in C:N ratio and cation exchange capacity during composting of organic residues*

Material	C:N ratio						Cation exchange capacity [c mol (p^+) kg^{-1}]					
	1st Day			150th Day			1st Day			150th Day		
	EF	EE	Mean	EF	EE	Mean	EF	EE	Mean	EF	EE	Mean
ML	33.77	33.01	33.39	13.62	13.53	13.57	34.33	36.50	35.42	80.90	89.83	85.37
CL	31.52	31.84	31.68	13.00	15.76	14.38	29.33	28.00	28.67	64.83	74.17	69.50
SL	46.22	46.49	46.35	14.31	14.48	14.39	36.83	38.00	37.42	83.00	90.67	86.83
AL	42.85	42.34	42.59	14.57	13.92	14.24	35.00	40.67	37.83	77.67	84.83	81.25
Mean	38.59	38.42		13.87	14.42		33.87	35.79		76.60	84.87	
	M effect	E effect	M x E effect	M effect	E effect	M x E effect	M effect	E effect	M x E effect	M effect	E effect	M x E effect
S.E.$\pm$	0.68	0.48	0.96	0.37	0.26	0.53	2.60	1.84	3.68	1.34	0.95	1.90
C.D. at 5%	2.06	NS	NS	NS	NS	1.6	2.91	NS	NS	4.08	2.88	NS

ML-Mango leaves; EF-*Eisenia foetida*; M effect-Material effect
NS-Non significant; EE-*Eudrilus eugineae*; E effect -Earthworm effect
SL-Shivan leaves; CL-Cashew leaves
AL-Ain leaves; MxE effect-Interaction effect

The interaction of material with earthworm on CEC was found to be non significant. The lowest CEC value was observed in cashew leaves inoculated with *E. foetida* at 150th day of composting. There was a steady increase in CEC of all the treatments from 1st to 150th day of composting. Dhawan and Kide (1994) found that initially CEC of compost product prepared from sugarcane trash and cow dung slurry was 37.1 c mol(p^+) kg^{-1} which increased upto 122.8 c mol (p^+) kg^{-1} after 120 days of composting period.

Changes in humus fractions

Humic acid (%)

From the data presented in Table 2 it is evident that, use of various organic residues resulted in significant increase in humic acid content on 1st and 150th day of composting. Initially maximum humic acid content was noted in shivan leaves (5.60%) followed by ain leaves (5.43%), cashew leaves (5.35%) and mango leaves (4.19%). On the last day i.e. 150th day of composting, shivan leaves recorded significantly highest humic acid content (7.99%) than cashew leaves (6.83%) and mango leaves (6.52%) and was at par with ain leaves (7.81%). The humic acid content was found to be higher in shivan leaves as compared to cashew leaves and mango leaves which may be due to less biodegradability of these materials containing higher proportion of lignin. Jadhav (1995) also reported maximum quantity of humic acid in compost prepared from forest leaves followed by cow dung, cashew leaves, mango leaves, local grass and farm waste.

Humic acid content was found to increased significantly on 150th day of composting, due to effect of inoculation of earthworms. The enhancement in humic acid production due to earthworm activity may be due to proliferation of microbes required for humification. Between the two species of earthworms, *E. euginae* was observed to be significantly superior over *E. foetida*. On the last day of observations maximum humic content (7.39%) was found due to inoculation of *E. eugineae* where as it was 7.09 percent in substrates inoculated with *E. foetida*. Zacheruah and Chhonkar (2004) reported significant increase in humic acid content due to inoculation of *E. foetida* over uninoculated samples. Humic acid content was 12.15 per cent and 11.82 per cent in inoculated and uninoculated samples, respectively.

As regards the interaction effect of earthworm species with various organic residues, the highest humic acid content to the tune of 7.44 per cent was found in T_3 where Shivan leaves were included with *E foetida* and it was at par with T_4 (AL + EF), T_7 (SL+EE), T_8 (AL + EE) and T_6 (CL + EE). The lowest value was noted in treatment. T_1 where mango leaves were inoculated with E. *foetida*. Inoculation of both the species of earthworms in different organic residues significantly increased the humic acid content of final composts, thus signifying the role of

***Table 2.** Changes in humic and fulvic acid during composting of organic residues*

Material	Humic acid (%)						Fulvic acid (%)					
	1st Day			150th Day			1st Day			150th Day		
	EF	EE	Mean	EF	EE	Mean	EF	EE	Mean	EF	EE	Mean
ML	4.18	4.20	4.19	6.13	6.92	6.52	2.52	2.44	2.48	4.14	4.24	4.19
CL	5.28	5.42	5.35	6.38	7.29	6.83	2.38	2.35	2.36	3.81	4.00	3.90
SL	5.52	5.68	5.60	8.24	7.75	7.99	2.85	2.79	2.81	5.32	5.13	5.22
AL	5.32	5.54	5.43	8.02	7.60	7.81	2.72	2.78	2.75	5.29	5.01	5.15
Mean	5.07	5.21		7.19	7.39		2.62	2.59		4.64	4.60	
	M effect	E effect	M x E effect	M effect	E effect	M x E effect	M effect	E effect	M x E effect	M effect	E effect	M x E effect
S.E.±	0.18	0.13	0.26	0.08	0.06	0.12	0.12	0.09	0.18	0.10	0.07	0.14
C.D. at 5%	0.55	NS	NS	0.28	0.18	0.35	NS	NS	NS	0.30	NS	NS

ML-Mango leaves EF-*Eisenia foetida* M effect-Material effect
NS-Non significant EE-*Eudrilus eugineae* E effect –Earthworm effect
SL-Shivan leaves CL-Cashew leaves
AL-Ain leaves MxE effect-Interaction effect

earthworms in humus production. The humic acid content was highest (8.24) where shivan leaves were inoculated with *E. foetida* and lowest value of 6.13 per cent was observed when mango leaves were inoculated with *E. foetida* on 150th day of decomposition. The percent increase in humic acid was maximum (64.76%) in T_5 where mango leaves were inoculated with *E. eugineae*. The high humification of castings was reflected in the decreased C:N ratio which is in agreement with the findings of Riffalda and Levi Minzi (1983).

Fulvic acid (%)

From the data presented in Table 2, it is evident that there was significant increase in fulvic acid. On 150th day of composting highest value of 5.22 per cent was recorded in shivan leaves where as lowest value of 4.19 per cent was noted in mango leaves. The variation in fulvic acid content in the compost of various materials may be due to variation in their chemical constituents. The results due to inoculation of earthworm species and interaction effects of organic residues with species of earthworms were found to be non significant.

CONCLUSIONS

On the basis of findings of the present investigation, it could be concluded that amongst the various organic residues evaluated, shivan leaves were observed to be the best source for rapid composting followed by ain leaves. The earthworm inoculation coupled with EM solution enhanced the composting process. Among the two earthworm species *Eudrilus eugineae* was superior to *Eisenia foetida* in respect of all the chemical properties. However, the changes in biological properties during composting of organic residues needs to be studied in future.

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