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Efficacy of *Eisenia foetida* species of Earthworm and Quality of Vermicompost in Relation to Plant Residues

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Abstract

Efficacy of *Eisenia foetida* species of earthworm and quality of vermicompost was evaluated using six types of plant residues *viz*. legume residues, maize residues, rice residues, forest residues, banana residues and pineapple residues. Higher earthworm population was recorded with pineapple residues, while maximum multiplication rate and earthworms biomass were observed under forest residues. Forest and banana residues required least and rice residues required longest duration for vermicomposting. Higher vermicompost production was recorded under pineapple residues. The pH of vermicompost was slightly alkaline with reasonable amount of soluble salts. Organic carbon content and C:N ratio reduced reasonably at maturity. Nutrients content increased gradually during vermicomposting and maximum was recorded at maturity. Among the plant residues, legume residue was found to be more suitable for vermicomposting due to higher amount of N, P and S, while banana and forest residues were found to be more suitable with regard to K and Ca contents, respectively. Efficacy of earthworms was high in forest residues with concerned to their multiplication and biomass gained.

Keywords: Plant residues, *Eisenia foetida,* vermicompost, C:N ratio, nutrient composition

Introduction

Vermicompost is becoming popular as a major component of organic farming system because of its richness in several useful micro floras *viz. Azospirillum, Actinomycetes, Phoxspor and Bacillus* which multiply fast through the digestive system of earthworm. Various enzymes, auxin and plant growth regulators like gibberellins are found in vermicompost. Nitrogen fixing bacteria are found in earthworms gut and casts and high nitrogenase activity, meaning greater rates of N-fixation are found in casts when compared with surrounding soil[4]. It offers a good solution to agro-wastes, being burned by farmers, to recycle it for sustainable agriculture development[3] in more efficient, economical and environmental friendly manner. Realizing the important benefits of vermicomposting in agriculture and availability of different plant residues in sufficient quantities, the present study was taken up to evaluate the effect of different plant residues on efficacy of earthworm and quality of vermicompost.

Materials and Methods

A pot trial was conducted in the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema during 2015. Experimental site is situated at the geographical location of $25^0 45^' 45^{''}$N latitude and $93^0 51^' 45$”E longitude at an altitude of 310 m above mean sea level. The climate of the experimental site is sub humid tropical with annual rainfall between 200-250 cm. Mean temperature ranges from 21^0C to 30^0C during summer and rarely goes below 8^0C during winter due to high atmospheric humidity in the region. The experiment was conducted with six types of plant residues *viz.* legume residues (soybean & green gram stover), maize residues, rice residues, forest residues, banana residues (leaves & pseudo stem) and pineapple residues in complete randomized design with four replications. Duncan multiple range test (DMRT) was used for comparison and ranking of residues. Five kg capacity cement pots, without bottom hole were used for vermicompost making. Each pot was filled with 100 g of soil, 125 g of partially decomposed cattle dung, 1.5 kg dried chopped plant residues on 15th February, 2015 and allowed to partial decomposition for 25 days. *Eisenia foetida species* of earthworms @ 15 per pot (10 per kg of plant residues) were released in the pots on 12th March, 2015. The pots were covered with gunny bags. Water was applied with the help of sprinkler at alternative days to maintain moisture content about 60-65%. At maturity, watering was stopped 2-3 days ahead. The compost was then piled and left for a couple of hours under ambient condition. When all earthworms moved down the upper portion of heap was separated and the lower portion was sieved to separate the earthworms from vermicompost. Juvenile and adult earthworms was counted after separating from vermicompost and weighed for their biomass. Vermicompost production was estimated after removing of the worms from the vermicompost. Vermicompost samples were tested for its various properties. Nutrient content was determined at three stages *viz.* at initial stage, at 50 days and at harvest. Organic carbon, N, P, K, S and Ca contents were analyzed adopting the standard procedures. The C:N ratio was calculated by dividing the organic carbon with nitrogen.

Results and Discussion

Earthworm biomass ranged from 73.0 to 95.0 g pot^{-1} with a mean of 85.6 g pot^{-1} (Table 1). The data further revealed that highest biomass gain per day (1.07 g day^{-1}) was recorded under forest residues and the lowest (0.77 g day^{-1}) was recorded under maize and legume residues. Superiority of plant residues for biomass gain can be arranged as forest residues > banana residues > pineapple residues > rice residues > maize residues = legume residues. Forest residues was reported more suitable for multiplication of earthworms possibly due to low C:N ratio. Highest worms biomass was recorded with rice residues might be due to availability of long period for biomass gaining. Earthworm population ranged from 350 to 469 with mean value of 420 per pot. Maximum earthworm population was recorded in pineapple residues, while minimum was recorded with legume residues. Maximum earthworm multiplication rate (5.3 per day) was observed with forest residues. However, minimum rate of multiplication (3.6 per day) was recorded with legume residues. Possible reason of these results is that the forest residues contained less organic carbon content with narrow C:N ratio might be caused high rate of earthworm multiplication. Furthermore, pineapple residues required more duration for vermicomposting which provided long time to earthworm multiplication resulted more number of earthworms per pot. Irrespective of substrates, the vermicomposting duration varied from 85.0 to 115.0 days with a mean value of 96 days. Forest and banana residues required least time (85 days) for vermicomposting, while rice residues needed longer duration (115 days) for vermicomposting. This might be due relatively low C:N ratio of forest and banana residues which makes them more eatable and therefore readily accepted by earthworms. Rice residues consumed long duration to convert in similar quality of vermicompost might be due to high amount of polysaccharides caused less acceptable to earthworms. Vermicompost production varied from 0.90 kg to 1.47 kg pot^{-1} with a mean value of 1.20 kg pot^{-1}. Superiority of plant residues for vermicompost yield can be arranged as pineapple residues > banana residues > maize residues > rice residues > legume residues > forest residues. Biochemical composition and decomposability of plant residues might be affected digestibility and decay of residues resulted variation in vermicompost yield[6]. The pH of vermicompost ranged from 6.69 to 8.11 with a mean value of 7.31. Maximum pH (8.11) was observed in pineapple residues vermicompost while minimum pH (6.69) was noticed in vermicompost of forest residues. Possible reason of variation in pH might be that various plant residues released variable quantities of hydrogen ions upon the decomposition resulted variation in pH of vermicompost. Irrespective of plant residues used, electrical conductivity (EC) of vermicompost varied from 1.08 to1.88 dSm^{-1}. Vermicompost of rice residues gave highest EC value (1.88 dSm^{-1}) while lowest EC (1.08 dSm^{-1}) recorded in vermicompost of maize residues. Variation in biochemical composition of plant residues, which govern quantities of released cations and anions during decomposition, might be caused variation in EC of vermicompost. Highest initial C:N ratio (81.3) was recorded in rice residues and the least (19.3) was recorded in forest residues. A critical examination of results revealed that C:N ratio was decreased drastically from initial to maturity of vermicompost. The C:N decreased by 39.6 and 66.4% at 50 days and maturity, respectively over initial. Higher C:N ratio indicated slow degradation of residues and the lower C:N ratio indicated the higher efficiency level of mineralization by the species. Addition of nitrogen by worms in the form of mucus and nitrogenous excretory material and simultaneously gaseous loss of carbon through microbial respiration caused reduced C:N ratio. Furthermore, microbial population and their activities enhanced during decomposition which utilized carbon for their energy requirement caused transformation of soluble nitrogen to microbial protein thereby preventing nitrogen loss[2].

Organic carbon content markedly reduced during vermicomposting of plant residues (Table 2). At 50 days and maturity, organic carbon content reduced by 20.5 and 41.3%, respectively over initial carbon content of plant residues. It might be due to utilization of carbon by earthworms and microorganism for their energy requirement and gaseous loss of carbon during decomposition**.** Highest initial N content (1.50%) was recorded in legume residues and lowest (0.60%) in rice residues. Nitrogen content enhanced from 0.97% in initial to 1.25% at 50 days and to 1.56% at maturity. At maturity, maximum nitrogen content (2.30%) was recorded in legume residues vermicompost, while lowest N content (0.96%) was recorded in vermicompost of banana residues. Nitrogen content at 50 days and maturity improved by 28.8 and 60.8% as compared to initial N content of plant residues. Loss of carbon during decomposition and mineralization of organic matter resulted enhanced N content**.** The P, K, S and Ca content enhanced gradually with vermicomposting time. Among the residues used, P content was found to be highest in pineapple residues (0.34%), K and S in banana residues (2.21and 0.34%, respectively) and Ca in legume residues (0.89%). At 50 days, maximum nutrients content was noticed in those plant residues which initially contained high amount of nutrients. However, at maturity, high amount of phosphorus and sulphur were recorded in legume residues, potassium in banana residues and calcium in forest residues vermicompost. Possible reason of increased nutrients might be due to loss of carbon during vermicomposting. A gradual enhancement of nutrients content towards maturity of vermicompost was also reported earlier[1].

Conclusion

From the present study it was concluded that for multiplication of earthworm, forest residue was found more suitable. Among the plant residues used for preparation of vermicompost, legume residue was found most suitable because its vermicompost contained high amount of N, P and S. The K content was recorded highest in the vermicompost prepared from banana residue while Ca content was recorded highest in the vermicompost prepared from forest residue.

Table 1 Effect of plant residues on performance of earthworm, production and quality of vermicompost

Plant residues	Biomass of earthworm (g pot^{-1})	Earthworm population (pot^{-1})	Vermicomposting duration (days)	Vermicompost production (kg pot^{-1})	pH	EC (dSm^{-1})	C:N ratio		
							Initial	At 50 days	At maturity
SR	73.0^{d}	350^{f}	95^{c}	1.06^{c}	7.48^{b}	1.19^{c}	34.1^{d}	22.3	16.1^{b}
				(5.82)	(15.87)	(6.22)	(34.7)	(28.1)	(23.8)
MR	81.0^{c}	397^{e}	105^{b}	1.26^{b}	7.31^{bc}	1.08^{c}	58.6^{c}	38.3^{b}	15.5^{b}
				(6.36)	(15.70)	(5.90)	(49.7)	(38.0)	(23.3)
RR	95.0^{a}	469^{a}	115^{a}	1.11^{c}	6.81^{c}	1.88^{a}	81.3^{a}	47.7^{a}	30.3^{a}
				(5.96)	(15.13)	(7.83)	(64.1)	(43.4)	(33.6)
FR	91.2^{b}	451^{b}	85^{d}	0.90^{d}	6.69^{c}	1.45^{b}	19.3^{f}	14.5^{e}	9.4^{d}
				(5.35)	(15.00)	(6.90)	(26.7)	(22.4)	(17.9)
BR	89.2^{b}	440^{c}	85^{d}	1.43^{a}	7.48^{b}	1.70^{a}	22.3^{e}	14.6^{e}	11.7^{c}
				(6.80)	(15.86)	(7.49)	(28.0)	(22.1)	(20.1)
PR	84.0^{c}	411^{d}	95^{c}	1.47^{a}	8.11^{a}	1.17^{c}	64.6^{b}	31.7^{c}	11.1^{c}
				(6.90)	(16.54)	(6.20)	(52.0)	(34.3)	(19.3)
CD *(P=0.05)*	2.32	6.10	2.02	0.55	0.93	0.55	1.18	1.37	1.40
Average	85.6	420	96	1.20	7.31	1.41	46.7	28.2	15.7

Figures in parenthesis are angular transformed values

Table 2 Change in the composition of plant residues during vermicomposting

Plant residues	Nutrient composition (%)																	
	Organic carbon			Nitrogen			Phosphorus			Potassium			Sulphur			Calcium		
	Initial	At 50 days	At maturity	Initial	At 50 days	At maturity	Initial	At 50 days	At maturity	Initial	At 50 days	At maturity	Initial	At 50 days	At maturity	Initial	At 50 days	At maturity
LR	51.1^{a}	43.6^{a}	37.0^{a}	1.50^{a}	1.95^{a}	2.30^{a}	0.28^{b}	0.56^{a}	0.87^{a}	0.74^{c}	1.11^{b}	1.42^{b}	0.25^{b}	0.37^{a}	0.45^{a}	0.89^{a}	1.04^{a}	1.20^{b}
	(45.4)	(41.1)	(37.6)	(7.05)	(8.02)	(8.66)	(2.99)	(4.28)	(5.31)	(4.92)	(6.05)	(6.82)	(2.84)	(3.40)	(3.79)	(5.42)	(5.77)	(6.22)
MR	52.5^{a}	40.7^{b}	28.2^{b}	0.90^{b}	1.30^{c}	1.89^{b}	0.14^{bc}	0.26^{c}	0.44^{cd}	0.98^{b}	1.07^{bc}	1.40^{b}	0.11^{c}	0.29^{a}	0.31^{b}	0.54^{b}	0.77^{b}	0.84^{c}
	(46.2)	(39.3)	(32.3)	(5.42)	(6.57)	(7.87)	(2.14)	(2.96)	(3.80)	(5.69)	(5.90)	(6.81)	(1.90)	(3.10)	(3.19)	(4.17)	(5.02)	(5.28)
RR	49.0^{b}	42.7^{a}	36.0^{a}	0.60^{e}	0.89^{d}	1.18^{c}	0.18^{bc}	0.35^{b}	0.51^{c}	0.89^{bc}	1.17^{b}	1.48^{b}	0.13^{c}	0.16^{b}	0.19^{c}	0.30^{c}	0.95^{a}	1.81^{a}
	(44.2)	(40.6)	(36.9)	(4.43)	(5.42)	(6.20)	(2.46)	(3.40)	(4.06)	(5.44)	(6.16)	(6.99)	(2.04)	(2.26)	(2.53)	(3.12)	(5.57)	(7.74)
FR	26.6^{c}	22.7^{d}	16.9^{c}	1.38^{b}	1.56^{b}	1.80^{b}	0.16^{bc}	0.29^{c}	0.50^{c}	1.07^{b}	1.20^{b}	1.40^{bc}	0.13^{c}	0.23^{b}	0.30^{b}	0.56^{b}	0.98^{a}	1.68^{a}
	(31.0)	(28.2)	(24.5)	(6.71)	(7.16)	(7.71)	(2.23)	(2.97)	(4.01)	(5.89)	(6.24)	(6.76)	(1.97)	(2.59)	(3.08)	(4.21)	(5.60)	(7.39)
BR	15.5^{d}	12.4^{e}	11.4^{e}	0.71^{d}	0.85^{d}	0.96^{d}	0.22^{b}	0.34^{b}	0.41^{d}	2.21^{a}	2.87^{a}	3.40^{a}	0.34^{a}	0.29^{a}	0.18^{c}	0.23^{d}	0.35^{d}	0.47^{d}
	(23.1)	(20.5)	(19.8)	(4.80)	(5.32)	(5.64)	(2.72)	(3.37)	(3.64)	(8.51)	(9.72)	(10.63)	(3.33)	(3.08)	(2.47)	(2.72)	(3.40)	(3.94)
PR	49.1^{b}	31.1^{c}	13.0^{d}	0.76^{d}	0.98^{d}	1.17^{c}	0.34^{a}	0.50^{a}	0.65^{b}	0.52^{d}	0.83^{c}	1.19^{c}	0.14^{c}	0.20^{b}	0.27^{bc}	0.61^{b}	0.45^{c}	0.30^{e}
	(44.1)	(33.9)	(21.4)	(5.05)	(5.65)	(6.20)	(3.39)	(4.02)	(4.53)	(4.16)	(5.16)	(6.22)	(2.05)	(2.47)	(2.89)	(4.42)	(3.81)	(3.02)
CD *(P=0.05)*	0.91	1.07	1.04	0.25	0.39	0.57	0.30	0.32	0.27	0.46	0.55	0.47	0.35	0.31	0.26	0.37	0.35	0.50
Average	40.6	32.2	23.8	0.97	1.25	1.56	0.22	0.38	0.56	1.07	1.37	1.70	0.18	0.25	0.27	0.51	0.75	1.04

Figures in parenthesis are angular transformed values

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