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EFFECT OF VARIOUS SUBSTRATES ON PERFORMANCE OF EARTHWORM AND QUALITY OF VERMICOMPOST

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ABSTRACT

An experiment was conducted at SASRD Medziphema to study the effect of various substrates on performance of earthworm and quality of vermicompost. Six substrates viz. forest litter; banana pseudo stem, pineapple stover, soybean stover, maize stover and paddy straw were tested in complete randomized design with four replications using earthworm species Eisenia foetida. The higher earthworm density was recorded with pineapple stover. Higher and lower rate of earthworm multiplication was observed with forest litter and soybean stover substrates, respectively. Biomass gain by earthworms was more under forest litter substrate as compared to others. Duration required by forest litter and banana pseudo stem was found the least, while paddy straw required longer duration for vermicomposting. Higher vermicompost yield was recorded under pineapple stover substrates. Mean pH of vermicompost was slightly alkaline with reasonable amount of soluble salts. Organic carbon content and C:N ratio decreased remarkably at maturity. Organic carbon and C:N ratio reduced by 41.4% and 66.0%, respectively at maturity. The N, P, K, Ca, Mg and S contents increased progressively during vermicomposting period and maximum contents of these nutrients was recorded at maturity. At maturity, N, P, K, Ca, Mg and S contents enhanced by 76.1, 154.5, 54.5, 103.9, 140.0 and 50.0% over initial nutrient contents. Among the substrates, soybean stover was found more suitable for preparation of vermicompost due to higher amount of N, P and S. The K and Mg contents were recorded highest in the vermicompost prepared from banana pseudo stem and forest litter, while higher Ca content was recorded in forest litter vermicompost. However, forest litter was found more suitable for multiplication of earthworms.

Keywords: Substrates, *Eisenia foetida,* vermicompost, C:N ratio, nutrient content

INTRODUCTION

Vermicomposting is a promising method of transforming unwanted and virtually unlimited supplies of organic wastes into usable substrates. In this process, the digestive tracts of certain earthworm species are used to stabilize organic wastes (Ismail, 1997). The final product is an odorless peat-like substance, which has good structure, moisture-holding capacity, relatively large amounts of available nutrients, and microbial metabolites that may act as plant growth regulators (Paul and Metzger, 2005). It is based on the capacity of earthworms to use as feed organic waste from various sources such as crop residues remaining after deforestation, vegetable debris from greenhouses, but also from the field, the waste left after cleaning the gardens and parks, damaged fruits and vegetables. All of them are converted into organic fertilizer with a high content of macro and micro elements and humus.Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly useful in raising seedlings and for crop production. It is becoming popular as a major component of organic farming system Vermicompost is rich in several micro floras *viz. Azospirillum, Actinomycetes, Phoxspor and Bacillus* which multiply fast through the digestive system of earthworm. Several enzymes, auxin and complex growth regulators like gibberellins are found in vermicompost which are not generally present in different soil and environment conditions. Nitrogen fixing bacteria are found in the gut of earthworms and in earthworm casts, and higher nitrogenase activity, meaning greater rates of N-fixation are found in casts when compared with surrounding soil (Simek and Pizl, 1989). Vermicompost contains major and minor nutrients in plant available forms, enzymes, vitamins and plant growth hormones. It has a more beneficial impact on plants than normal compost. Vermicomposting offers a solution to tones of organic agro-wastes that are being burned by farmers and to recycle and reuse these refuse to promote our agricultural development in more efficient, economical and environmental friendly manner. Realizing the important benefits of vermicomposting in agriculture and availability of different substrates in huge quantities, the present study was undertaken to evaluate the effect of various substrates on performance of earthworm and quality of vermicompost in Nagaland condition.

MATERIALS AND METHODS

A pot experiment was conducted in the green house, Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema during 2014. The green house is located in the foot hills of Nagaland at an altitude of 310 m above mean sea level with the geographical location of $25^0 45^{'} 45^{"}$N latitude and $93^0 51^{'} 45$"E longitude. The climate of the region is sub humid tropical with annual rainfall between 2000-2500 mm. Mean temperature ranges from 21^0C to 30^0C during summer and rarely goes below 8^0C during winter due to high atmospheric humidity. The experiment was conducted with six substrates *viz.* forest litter, banana pseudo stem, pineapple stover, soybean stover, maize stover and paddy straw in complete randomized design with four replications. Duncan multiple range test (DMRT) was used for comparison of mean and ranking of substrates. Earthen pots of 5 kg capacity without bottom hole were used for the preparation of vermicompost. Each pot was filled with 100 g of soil, 150 g of partially decomposed cow dung, 1.5 kg air dried chopped substrates on 3^{rd} March, 2014 and allowed to partial decomposition for 25 days. Adult earthworms (*Eisenia foetida)* @10 per kg of substrate (15 per pot) were released in the pot on 28^{th} March, 2014. The pots were covered with gunny bags and kept in shade. Watering was done at alternative days. Moisture content was maintained at about 65%. When the compost was ready, watering was stopped 2-3 days ahead. The compost was then piled and left under ambient condition for a couple of hours. When all the worms moved down the heap in the bed, upper portion was separated and the lower portion was sieved to separate the earthworms from vermicompost. Earthworm both juvenile and adults was counted after sieving the vermicompost and weighed for their biomass. Vermicompost yield was estimated after separating of the earthworms. The vermicompost samples were tested for its physico chemical properties. Nutrient content was determined at different stages *viz.* initial stage, 45 days and at harvest adopting standard procedures (Tandon, 1993). The organic carbon was determined adopting the standard procedure (Jackson, 1973).The C:N ratio was calculated by dividing the organic carbon with nitrogen.

RESULTS AND DISCUSSION

Effect on density and biomass of earthworm

Density of earthworm varied from 348 to 467 with an average of 418 per pot (Table 1). Maximum and minimum earthworm density was recorded with pineapple stover and soybean stover, respectively. Highest rate of earthworm multiplication (5.6 per day) was observed with forest litter substrate and lowest (3.8 per day) in soybean stover. Possible reason of such results is that the pineapple stover required more days for vermicomposting and provided more time to earthworm multiplication resulted more earthworm density. Furthermore, less organic carbon content and narrow C:N ratio of forest litter caused high rate of earthworm multiplication. Biomass of earthworm ranged from 71.0 to 93.0 g pot^{-1} with a mean of 83.6 g pot^{-1}. A critical examination of data indicated that per day more biomass gain (1.12 g day^{-1}) was recorded under forest litter substrate and the least (0.79 g day^{-1}) was recorded under soybean and maize stover. On the basis of per day biomass gain, the superiority of substrates can be arranged as forest litter > banana pseudo stem > pineapple waste > paddy straw > soybean stover = maize stover. Forest litter substrate was found more suitable for multiplication of earthworms might be due to narrow C:N ratio. In other hand maximum earthworm biomass was recorded with pineapple stover possibly due to long duration availability for biomass gaining. These results are in accordance with those of Sharma (2003).

Effect on days required and yield of vermicompost

Irrespective of substrates, the vermicomposting duration varied from 80.0 to 110.0 days with a mean value of 91.7 days. Number of days required by forest litter and banana pseudo stem was found the least for vermicomposting, while paddy straw required longer period for vermicomposting. This may be because of the relatively low C:N ratio of forest litter and banana pseudo stem which makes them more palatable and therefore more readily accepted by earthworms. These results are in confirmation with those of Manna *et al.* (2003). Paddy straw required longer time to obtain similar quality of vermicompost might be due to high amount of cellulose, hemicelluloses and lignin caused less acceptable to earthworms (Kannan *et al.,* 2008 and Viji and Neelanarayanan, 2013). Yield of vermicompost ranged from 0.88 kg to 1.45 kg pot^{-1} with a mean value of 1.18 kg pot^{-1}. On the basis of average vermicompost yield, superiority of substrates can be arranged as pineapple stover > banana pseudo stem > maize stover >paddy straw > soybean stover > forest litter. Variation in vermicompost yield might be due to variation in biochemical composition of substrates which affected digestibility and decomposition of substrates ultimately caused variation in yield of vermicompost.

Table 1: Effect of substrates on performance of earthworm and yield and quality of vermicompost

	Earth-worm density (pot^{-1})	Earthworm biomass (g pot^{-1})	Days required for vermin-composting	Yield of vermin-compost (kg)	pH	EC (dSm^{-1})	Organic carbon content (%)			C:N ratio		
							Initial	45 days	At harvest	Initial	45 days	At harvest
FL	449^{b}	89.2^{b}	80.0^{d}	0.88^{d}	6.71^{c}	1.44^{b}	26.63^{c}	22.73^{d}	16.97^{c}	20.57^{f}	14.78^{e}	9.29^{d}
		(70.9)		(5.36)	(15.01)	(6.88)	(31.07)	(28.47)	(24.31)	(26.97)	(22.61)	(17.74)
BPS	438^{c}	87.2^{b}	80.0^{d}	1.41^{a}	7.50^{b}	1.69^{a}	15.57^{d}	12.44^{e}	11.46^{e}	22.30^{e}	14.60^{e}	11.76^{c}
		(69.2)		(6.83)	(15.89)	(7.48)	(23.24)	(20.65)	(19.78)	(28.18)	(22.46)	(20.03)
PAS	409^{d}	82.0^{c}	90.0^{c}	1.45^{a}	8.13^{a}	1.16^{c}	49.11^{b}	31.17^{c}	13.07^{d}	62.41^{b}	31.97^{c}	11.27^{c}
		(64.9)		(6.92)	(16.56)	(6.19)	(44.49)	(33.93)	(21.19)	(52.19)	(34.42)	(19.59)
SS	348^{f}	71.0^{d}	90.0^{c}	1.04^{c}	7.50^{b}	1.18^{c}	51.17^{a}	43.60^{a}	37.01^{a}	32.74^{d}	22.46^{d}	16.27^{b}
		(57.4)		(5.84)	(15.89)	(6.21)	(45.67)	(41.32)	(37.47)	(34.90)	(28.27)	(23.78)
MS	395^{e}	79.0^{c}	100.0^{b}	1.24^{b}	7.33^{bc}	1.07^{c}	52.50^{a}	40.77^{b}	28.24^{b}	58.65^{c}	38.36^{b}	15.59^{b}
		(62.8)		(6.38)	(15.71)	(5.89)	(46.43)	(39.68)	(32.10)	(49.98)	(38.27)	(23.24)
PS	467^{a}	93.0^{a}	110.0^{a}	1.09^{c}	6.83^{c}	1.87^{a}	49.03^{b}	42.77^{a}	36.07^{a}	81.35^{a}	47.72^{a}	30.33^{a}
		(75.2)		(5.98)	(15.15)	(7.84)	(44.45)	(40.84)	(36.91)	(64.43)	(43.69)	(33.41)
CD *(P=0.05)*	5.86	2.36	1.92	0.53	0.93	0.54	0.90	1.09	1.06	1.16	1.35	1.43
Mean	418	83.6	91.7	1.18	7.33	1.40	40.67	32.25	23.80	46.34	28.31	15.75

Figures in parenthesis are angular transformed values
FL-forest litter, BPS-banana pseudo stem, PAS-pineapple stover, SS-soybean stover, MS, maize stover, PS-paddy straw

Effect on pH and EC of vermicompost

Irrespective of substrates, the pH of vermicompost varied from 6.71 to 8.13 with a mean value of 7.33. The highest pH was recorded in pineapple stover vermicompost (8.13) and the lowest pH was recorded in forest litter vermicompost (6.71). Various substrates released variable quantities of H^+ during decomposition which may cause variation in pH of vermicompost (Padmavathiamma *et al*, 2008). Electrical conductivity (EC) of vermicompost derived from different substrates ranged from 1.07 to1.87 dSm^{-1}. Paddy straw was observed to be highest EC (1.87 dSm^{-1}) and the least was recorded in maize stover (1.07 dSm^{-1}). The variation in EC of vermicompost might be due to variation in biochemical constituents of substrates. These findings are in accordance with those of Acevedo and Pire (2007).

Effect of substrates on the organic carbon and C:N ratio of vermicompost

Organic carbon content markedly decreased during vermicomposting period. At 45 days and maturity, mean organic carbon content decreased by 20.7 and 41.4%, respectively over initial carbon content. The loss of carbon during vermicomposting might be due to utilization of carbon by earthworms for their body development and gaseous loss of carbon during decomposition (Garg *et al.* 2006). Among the substrates used, the C:N ratio was found to be highest in paddy straw (81.35) and the least was recorded in forest litter (20.57). It was also observed that C:N ratio was decreased markedly from initial to the maturity. On the basis of average C:N ratio, at maturity it was decreased by 66.0% as compared to initial C:N ratio of the substrates. The gaseous loss of carbon through

Table 2: Effect of substrates on nutrient content of vermicompost

Substrate	Nitrogen			Phosphorus			Potassium			Calcium			Magnesium			Sulphur		
	Initial	45 days	At harvest	Initial	45 days	At harvest	Initial	45 days	At harvest	Initial	45 days	At harvest	Initial	45 days	At harvest	Initial	45 days	At harvest
FL	1.37^{b}	1.55^{b}	1.81^{b}	0.15^{bc}	0.27^{c}	0.49^{c}	1.05^{b}	1.19^{b}	1.38^{bc}	0.55^{b}	0.96^{a}	1.66^{a}	0.12^{d}	0.24^{e}	0.45^{c}	0.12^{c}	0.21^{b}	0.28^{b}
	(6.72)	(7.15)	(7.74)	(2.22)	(2.95)	(4.02)	(5.88)	(6.26)	(6.74)	(4.24)	(5.61)	(7.39)	(1.98)	(2.82)	(3.85)	(1.98)	(2.58)	(3.05)
BPS	0.71^{d}	0.85^{de}	0.97^{cd}	0.22^{b}	0.34^{b}	0.41^{d}	2.21^{a}	2.87^{a}	3.40^{a}	0.23^{d}	0.35^{d}	0.47^{d}	0.38^{a}	0.97^{a}	1.28^{a}	0.34^{a}	0.29^{a}	0.18^{c}
	(4.83)	(5.30)	(5.66)	(2.71)	(3.35)	(3.66)	(8.52)	(9.75)	(10.60)	(2.74)	(3.39)	(3.92)	(3.50)	(5.65)	(6.50)	(3.35)	(3.06)	(2.45)
PAS	0.78^{d}	0.97^{d}	1.17^{c}	0.35^{a}	0.49^{a}	0.63^{b}	0.53^{d}	0.82^{c}	1.17^{c}	0.60^{b}	0.44^{c}	0.28^{e}	0.18^{c}	0.25^{e}	0.39^{d}	0.13^{c}	0.18^{b}	0.25^{bc}
	(5.07)	(5.63)	(6.21)	(3.39)	(4.00)	(4.55)	(4.16)	(5.18)	(6.20)	(4.45)	(3.80)	(3.00)	(2.43)	(2.88)	(3.59)	(2.07)	(2.45)	(2.88)
SS	1.52^{a}	1.94^{a}	2.29^{a}	0.27^{b}	0.55^{a}	0.86^{a}	0.73^{c}	1.13^{b}	1.40^{b}	0.90^{a}	1.02^{a}	1.17^{b}	0.29^{b}	0.37^{d}	0.46^{c}	0.25^{b}	0.36^{a}	0.43^{a}
	(7.07)	(8.00)	(8.68)	(2.98)	(4.26)	(5.33)	(4.91)	(6.07)	(6.80)	(5.44)	(5.78)	(6.20)	(3.06)	(3.47)	(3.87)	(2.86)	(3.42)	(3.77)
MS	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}	0.54^{b}	0.77^{b}	0.84^{c}	0.45^{a}	0.64^{b}	0.85^{b}	0.11^{c}	0.29^{a}	0.31^{b}
	(5.44)	(6.55)	(7.89)	(2.13)	(2.94)	(3.80)	(5.68)	(5.92)	(6.80)	(4.19)	(5.04)	(5.26)	(3.83)	(4.59)	(5.29)	(1.92)	(3.10)	(3.17)
PS	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}	0.30^{c}	0.95^{a}	1.81^{a}	0.37^{a}	0.56^{c}	0.87^{b}	0.13^{c}	0.16^{b}	0.19^{c}
	(4.44)	(5.40)	(6.21)	(2.45)	(3.39)	(4.08)	(5.42)	(6.18)	(6.98)	(3.14)	(5.59)	(7.72)	(3.50)	(4.28)	(5.34)	(2.05)	(2.28)	(2.51)
CD *(P=0.05)*	0.24	0.38	0.58	0.29	0.33	0.26	0.47	0.54	0.45	0.37	0.34	0.49	0.40	0.23	0.24	0.33	0.33	0.25
Mean	0.88	1.25	1.55	0.22	0.38	0.56	1.10	1.38	1.70	0.51	0.75	1.04	0.30	0.51	0.72	0.18	0.25	0.27

Figures in parenthesis are angular transformed values

FL-forest litter, BPS-banana pseudo stem, PAS-pineapple stover, SS-soybean stover, MS, maize stover, PS-paddy straw microbial respiration and simultaneously addition of nitrogen by worms in the form of mucus and nitrogenous excretory material caused lowered the C:N ratio. Furthermore, this might be due to enhanced microbial activity those utilized carbon for their energy requirement caused transformation of soluble nitrogen to microbial protein thereby preventing nitrogen loss. Higher C:N ratio indicated slow degradation of substrate and the lower C:N ratio indicated the higher efficiency level of mineralization by the species. Similar results have also been reported by Gajbhiye and Satpute (2014).

Effect on nutrient contents of vermicompost

Among the six substrates used for vermicompost the initial N content was found to be highest in soybean stover (1.52%), while paddy straw had the lowest N content (0.60%). Overall N content increased from 0.88% in initial to 1.25% at 45 days of composting. Higher nitrogen content was recorded in case of soybean stover vermicompost (2.29%) at maturity followed by maize stover (1.89%) while the lowest N content was recorded in banana pseudo stem vermicompost (0.97%). Average N content increased from 0.88% to 1.55% during composting period. The N content at 45 days and maturity increased by 42.0 and 76.1% as compared to initial N content. Loss of carbon and mineralization of organic matter resulted increased N content (Lakshmi *et al*., 2014). It was observed that P, K, Ca, Mg and S contents had increased gradually during vermicomposting period. Among the substrates used for vermicompost the P content was found to be highest in pineapple stover (0.35%), K, Mg and S in banana pseudo stem (2.21,0.38 and 0.34%, respectively) and Ca in soybean stover (0.90%). At 45 days of vermicomposting, highest nutrient content was recorded in those substrates which contained initially high amount of nutrients. However at maturity, higher amount of P and S was recorded in soybean stover vermicompost, K and Mg in banana pseudo stem vermicompost and Ca in forest litter vermicompost. The P, K, Ca, Mg and S content at maturity enhanced by 154.5, 54.5, 103.9, 140.0 and 50.0% over initial content of respective nutrients of substrates. Possible reason of increased nutrients might be due to loss of carbon during vermicomposting. Aalok and Tripathi (2010) also reported the increased trend of nutrients at maturity of vermicomposting.

From the present investigation it can be concluded that among all the substrates used for vermicomposting, soybean stover was found to be the most suitable in Nagaland condition because vermicompost prepared from it contained better amount of N, P and S. The K and Mg contents were recorded highest in the vermicompost prepared from banana pseudo stem while Ca content was recorded highest in the vermicompost prepared from forest litter. However, for multiplication of earthworm, forest litter substrate was found more suitable.

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