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Waste recycling: Utilization of coffee grounds and kitchen waste in vermicomposting.

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Potential of spent mushroom substrate in vermicomposting

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ABSTRACT
The potential of spent mushroom substrate from saw dust in vermicomposting were found out through the growth and reproduction of earthworms including the nutrient elements of vermicompost produced at the end of vermicomposting. Five treatments in different ratio of cow dung : spent mushroom substrate were prepared as feed materials with four replicates for each treatment namely; 80:20 (T_1), 60:40 (T_2), 50:50 (T_3), 40:60 (T_4) and 20:80 (T_5). After 3 weeks of pre-composting followed by 7 weeks of vermicomposting, T_4 showed the highest percentage of growth and reproduction where mean of earthworms' numbers increases (M = 295.00, SD = 17.32, n = 4) while (M = 28.86, SD = 5.97, n = 4) for earthworms' weights. Furthermore, with the higher ratio of cow dung to spent mushroom substrate in T_1, vermicompost produced, showed highest percentage of macronutrient elements; N (1.90%), P (0.57%), and K (2.74%) compared to other treatments. Overall, the results reveal that spent mushroom substrate can be decomposed through vermicomposting by using *Lumbricus rubellus* with right ratio together with cow dung.

Keywords : macronutrient elements, *Lumbricus rubellus*, spent mushroom substrate, vermicomposting.

1. INTRODUCTION

Vermicomposting is a suitable alternate technology for conversion of different types of organic wastes (domestic as well as industrial) into value added material; vermicompost (Garg et al., 2006). Vermicomposting is the non-thermophilic biodegradation of organic material through the interaction between earthworms and microorganisms, whereby organic material residuals are fragmented rapidly into much finer particles by passing them through a grinding gizzard while maintaining nutrients. Use of earthworms for waste management, organic matter stabilization, soil detoxification and vermicompost production has been well documented (Kaviraj and Sharma, 2003; Lot et al., 2005; Suthar, 2006).

Spent mushroom substrates is a nutrient rich organic by product of mushroom industry where the primary source in mushroom substrates is wood saw dust, cotton waste, straw or corn cobs. The wood saw dust is one of the most common sources which is routinely used for the cultivation of king oyster mushroom; *Pleurotus eryngii* and winter mushroom; *Flammulina velutipes* (Kwak et al., 2007).

According to Bae et al. (2006), chemical composition of spent mushroom substrates from saw dust was natural detergent fiber 78.2%, acid detergent fiber 60.4%, hemicellulose 17.8%, cellulose 40.4%, lignin 20.0%, nonfibrous carbohydrate 7.8%, crude protein 7.2%, true protein/crude protein 69.4%, non-protein nitrogen/crude protein 30.6%, acid detergent fiber-crude/crude protein 36.4%, ether extract 2.1%, crude ash 4.7%, and dry matter 40.8%.

Equally, from the production of 1 kg of mushroom, 5 kg of spent mushroom substrates will be generated (Semple et al., 2001) where definitely dispose either by direct open burning or send it to the landfills. These spent mushroom substrates cannot be reuse in any manner as a result of contamination and the disposal of different types of wastes has become very important issue to maintain the healthy environment (Senapaty and Julka, 1993). Therefore, these nutrient rich of spent mushroom substrates need to fully utilized before final disposal.

Accordingly, this study was conducted to assess the potential of spent mushroom substrates in vermicompsting and the quality of vermicompost produced at the end of vermicomposting.

2. MATERIALS AND METHODS

2.1. Experimental design

Five treatments in different ratio of cow dung : spent mushroom substrate were prepared as feed materials with four replicates for each treatment namely; 80:20 (T_1), 60:40 (T_2), 50:50 (T_3), 40:60 (T_4) and 20:80 (T_5). Four replicates for each treatment were conducted in plastic bins of 45cm x 30cm x 30cm size. The use of cow dung in each treatment is only for bedding material at early stage before the earthworms can adapt with the treatments given. The high content of N in cow dung (Loh et al., 2005) is .

Started with one weeks of pre composting in order to avoid exposure of earthworms to high temperature during initial thermophilic stage (Nair et al., 2006), the experiment followed by ten weeks of vermicomposting. 60 weighted matured earthworms were introduced in each replicate as adapted from Kaviraj and Sharma (2003) and the moisture content of each replicate was maintained in range 60-70% by spraying the surface with water.

After ten weeks, the earthworms were sorted manually from the vermicompost produced. All earthworms were counted and weighted to find out the growth and reproduction rate. The vermicompost produced were sampled for nutrient elements analysis.

2.2. Statistical Analysis

One way ANOVA was done to analyze the significant difference of earthworms' weight and number between treatments during vermicomposting at 0.05% level of significance. Significance differences between initial and final numbers and weights of earthworms (*L. rubellus*) in each treatment were determined by paired samples t-test.

2.3. Nutrient elements analysis

Organic carbon in vermicompost produced was determined by the partially-oxidation method (Walkley & Black, 1934). N was estimated by Kjeldahl digestion. P was detected by using colorimetric. K was measured by ignition method using atomic absorption spectrophotometry. C/N ratio is analyzed through calculation.

3. RESULTS AND DISCUSSION

Table 1
Growth and reproduction of earthworms (weights and numbers) in different treatments

The growth and reproduction of earthworms (number and weight) for five different types of treatments is presented in Table 1. Generally, all plots in T_2, T_3 and T_4 showed positive results with the increasing number and weight compared to T_1 and T_5. In these two treatments, reduction of growth and reproduction of earthworm were recorded.

Fig.1
Mean of earthworms' growth and reproduction (weight and number) in different treatments

Statistically, the *F* value for the increasing of weight and number of earthworms are significant where F (df=4,15; p < 0.05) = 18.545 and F (df=4,15; p<0.05) = 72.420. Through the mean of four plots for all treatments, T_4 stated the highest gain in both number (M = 295.00, SD = 17.32, n = 4) while (M = 28.86, SD = 5.97, n = 4) for weight of earthworms. In contrast to T_1 where it stated negative mean in both number (M = -25.50, SD = 28.45, n = 4) and weight (M = -.8875, SD = 8.966, n = 4). The same situation was also recorded by Sangwan et al. (2008) after 8th week of vermicomposting that might be due to the exhaustion of earthworm feed in vermicomposters. According to Neuhauser et al. (1980), when earthworm (*E. foetida*) received food below a maintenance level, it loose weight at a rate which depended on the quantity and nature of its ingestible substrates.

The growth and reproduction could be related to the biochemical quality of feed (Flack and Hartenstein, 1984) that along with microbial biomass and decomposition activities (Suthar, 2006). Supported by Edwards (1998), who stated that the feeds provide earthworms with sufficient amount of easily metabolizable organic matter and non-assimilated carbohydrates favor the growth and reproduction of the earthworms (Edwards, 1988).

The differences between initial and final numbers and weights of earthworms (*L. rubellus*) are significant (p<0.05) in T_2, T_3 and T_4.

Table 2
Nutrient elements in vermicompost from five different types of treatments.

The nutrient elements in vermicompost from five different types of treatment are presented in Table 2. The higher ratio of cow dung compared to spent mushroom substrate in T_1, resulted a better quality of vermicompost compared to other treatments. According to Hand et al. (1998), the use of cow dung increase the nitrate-nitrogen content in vermicompost and initial N present in feed materials directly influence the N content in vermicompost (Suthar, 2006; Loh et al., 2005). In addition, the extents of N fixed by free living nitrogen-fixing bacteria also give significance influence to the N content in vermicompost (Kale et al., 1982).

With the small percentage of organic carbon compared to high percentage of N, lead to the lower C/N ratio in vermicompost of T_1 which is accepted maturity compared to other treatments. However, vermicompost produced from other treatments is also preferable except for T_4 and T_5 when the maturity degree of compost is below than 20 (Morais and Queda, 2003). Accoding to Pramanik et al. (2007), the increase in the earthworms' population lead to rapid decrease in C as CO_2 as well as water loss by evaporation during mineralization due to enhanced oxidation of the organic matter.

Other nutrient elements; P and K from vermicompost of T_1, also stated the highest percentage among to other treatments. According to Garg et al. (2006), P and K increased significantly in all the substrates with earthworm inoculated waste than in control; treatments without earthworms due to direct action of earthworm gut enzymes and indirectly by stimulation of the microflora (Satchell and Martein, 1984) due to bacterial and faecal phosphate activity of earthworms that probably lead towards mineralization and mobilization of phosphorous (Edwards and Lofty, 1972).

4. CONCLUSION

The spent mushroom substrate can be decomposed through vermicomposting by using *Lumbricus rubellus*. Growth and reproduction of earthworms were optimum at ratio 40:60 of cow dung : spent mushroom substrate (T_4). In other hands, T_1 produced a better quality of vermicompost when the macronutrient elements of it showed highest percentage of macronutrient elements; N (1.90%), P (0.57%), and K (2.74%) among to other treatments.

The results reveal that spent mushroom substrate from sawdust based is suitable in vermicomposting and with the specific ratio, it not only can accelerated the mineralization of nutrients but also proved as a better feed materials for vermiculture. Thus, the generation of organic waste from the agriculture sector indirectly can be reduce or eliminated especially in mushroom cultivation sectors.

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Table 1
Multiplication of earthworms (weights and numbers) in different treatments

Treatment	Plot	Weight of earthworms (g)		Earthworms weight gain (g)	Number of earthworms		Earthworms number gain
		Initial	Final		Initial	Final	
T_1	A1	10.42	4.48	-5.94	60	21	-39
	A2	12.47	9.02	- 3.45	60	32	-28
	A3	9.11	21.52	12.41	60	75	15
	A4	9.05	2.48	-6.57	60	10	-50
T_2	B1	8.2	11.17	3.5	60	210	150
	B2	8.23	13.82	5.59	60	220	160
	B3	7.47	13.51	6.04	60	237	177
	B4	8.77	13.38	4.61	60	282	222
T_3	C1	5.50	21.03	15.53	60	400	340
	C2	5.00	40.33	35.33	60	352	292
	C3	6.69	28.77	22.08	60	255	195
	C4	5.51	34.38	28.87	60	299	239
T_4	D1	10.17	30.42	20.25	60	380	320
	D2	7.56	38.03	30.87	60	350	290
	D3	5.81	39.87	34.06	60	340	280
	D4	5.91	36.18	30.27	60	350	290
T_5	E1	4.99	8.77	3.78	60	53	-7
	E2	7.58	6.00	-1.58	60	45	-15
	E3	3.49	10.41	6.92	60	70	10
	E4	3.55	8.13	4.58	60	47	-13

Note :
T_1 - Cow dung : Spent mushroom substrate (80:20)
T_2 - Cow dung : Spent mushroom substrate (60:40)
T_3 - Cow dung : Spent mushroom substrate (50:50)
T_4 - Cow dung : Spent mushroom substrate (40:60)
T_5 - Cow dung : Spent mushroom substrate (20:80)

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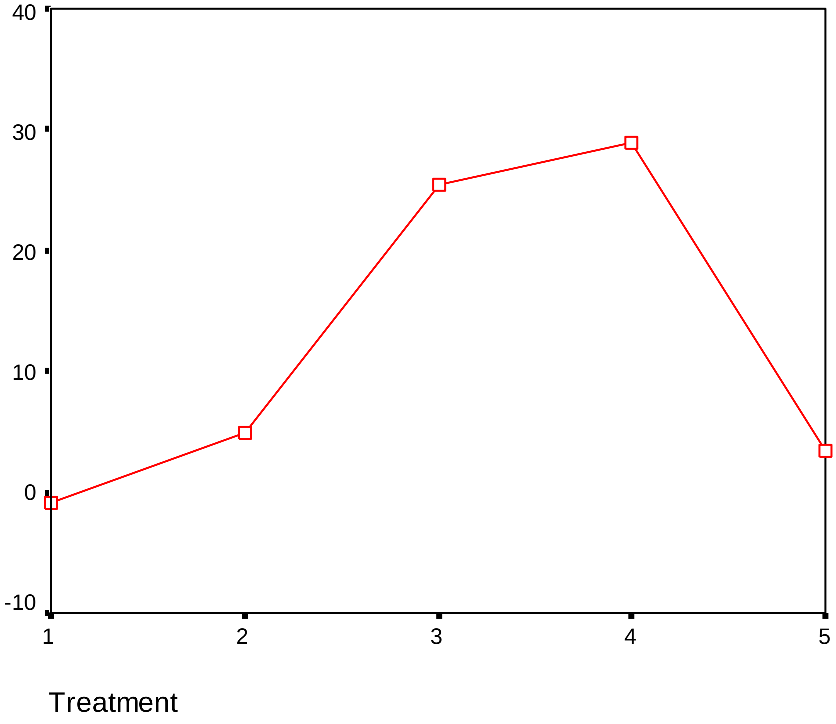
Fig.1
Mean of earthworms' growth and reproduction (weight and number) in different



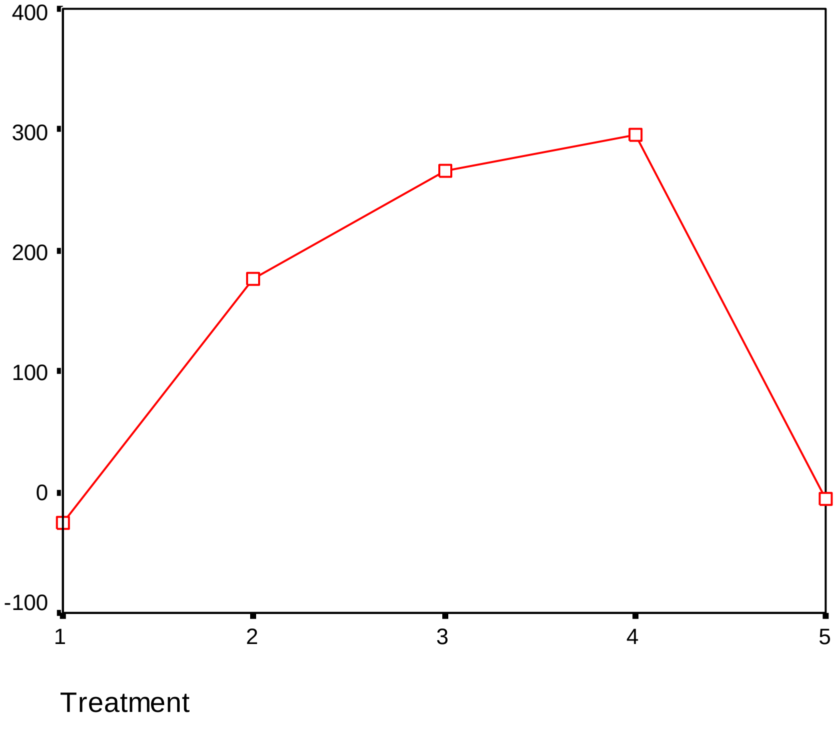


Table 2
Nutrient elements in vermicompost from five different types of treatments

	Vermicompost				
Nutrient elements	***T_1***	***T_2***	***T_3***	***T_4***	***T_5***
Organic carbon	16.88 %	23.51 %	23.96 %	19.66 %	32.14 %
Nitrogen (as N)	1.90 %	1.46 %	1.75 %	0.94 %	0.87 %
Phosphorus (as P)	0.57 %	0.38 %	0.46 %	0.24 %	0.23 %
Potassium (as K)	2.74 %	1.43 %	1.39 %	0.67 %	0.40 %
C/N ratio	8.9	16.1	13.7	20.9	36.9

Note :
T_1 - Cow dung : Spent mushroom substrate (80:20)
T_2 - Cow dung : Spent mushroom substrate (60:40)
T_3 - Cow dung : Spent mushroom substrate (50:50)
T_4 - Cow dung : Spent mushroom substrate (40:60)
T_5 - Cow dung : Spent mushroom substrate (20:80)