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Management of Water Hyacinth (*Eichhornia crassipes*) and Grass Clippings Through Biodung Mediated Vermicomposting

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ABSTRACT

Research study was carried out during 2006-07 at the University of Guyana campus to produce vermicompost on a large scale and assess the physicochemical changes that occur during the process of biodung and vermicomposting, as well as to assess the quality and quantity of the vermicompost harvested. The attempt was made to solve the problems of disposing organic waste by biodung composting and vermicomposting processes. The temperature changes in the predigestion of organic matter showed effective anerobic and aerobic decomposition process. The temperature of the biodung units rose to a maximum and then declined gradually to a constant temperature, bringing about reduction of organic waste free from harmful microbes. The results indicated that the vermicompost is highly rich in nutrient and the percentages of these nutrients in the compost vary as the process proceeded until their ideal concentrations for the promotion of plant growth reached. Vermicomposting of the water hyacinth+ grass (T2) resulted in high productivity of vermicompost followed by water hyacinth (T2) grass (T1).

Key words: Biodung composting, vermicomposting, physicochemical changes

INTRODUCTION

In Guyana, major drainage and irrigation water ways are plagued by large amounts of aquatic weeds, a major one being the water hyacinth (*Eichhornia crassipes*) which creates a problem of clogging because their petioles have air-filled bladders called arenchyma. In addition, transpiration from dense mats of water hyacinth can drain a water way at an incredible rate; a trench covered with *E. carasspies* loses water almost eight times faster than uncovered surfaces. This creates yet another problem of excessive loss of water during the dry seasons. The piling of grass clippings from play fields and lawns is usually an eye sore, since their bulk fills limited landfill sites quickly and takes a long time to decay. These problems can be solved by converting the above into useful organic fertilizer for agricultural use (Ansari, 2007).

Vermicomposting is the process of producing vermicompost by utilizing earthworms to turn organic waste into high quality compost that consists mainly of worm cast in addition to decayed organic matter, thus it serves as a nutrient rich natural fertilizer and soil conditioner (Ismail, 1997, 2005; Ansari and Ismail, 2001a). The earthworms, *Eisenia foetida* and *Lumbricus rubellas* used in vermicomposting occupy a different ecological niche (epigeics), living near the surface of the earth where there is a high concentration of organic matter; they are especially adapted to special conditions in rotting vegetation, compost and manure pile (Edwards, 2004).

Vermicompost and vermiculture associated with other biological inputs have been actually used to grow vegetables and other crops with much success (Ansari, 2008a-c). It has been found to be economically productive. Case studies conducted in several villages in Uttar Pradesh, India (1999-2000) several biofertilizers such as Nadeep compost, vermicompost, biodynamic preparations 500, cow pat pit and liquid manure were produced and applied on Paddy, wheat and potato and were compared with growth parameters using chemical fertilizers. The results indicated that when biofertilizers are applied in combinations had a positive impact on the yield parameters. The pest defender ratios were found to be less in organic fields compared to fields that were treated with chemical fertilizers. This evidence strongly advocates the concept of organic farming (Ansari and Ismail, 2001b). Thus organic farming is a self-sustained and economical system where bio fertilizers can be produced using agro waste, with less resource management. Additionally, organic farming is ecologically safe and economically viable (Ansari and Ismail, 2001b).

On the regional scene, at the demonstration and training center of the CARDI Jamaica Unit, a greenhouse study has shown enhanced pepper seedlings growth when treated with low levels of vermicompost compared to thermophillic compost, commercial and traditional potting mixtures (Simpson and Martin, 2001). In Guyana, a recent investigation into the recycling of sugar cane bagasse and rice straw to produce compost, using vermitechnology and using the compost on *Phaseolus vulgaris* concluded that, the physiochemical properties of the rice straw and the combinations (bagasse with rice straw) were beneficial and enhanced growth and yield of *Phaseolus vulgaris.* The soil chemical analysis also indicated improvement in nutrient content (Ansari and Jaikishun, 2010).

MATERIALS AND METHODS

Research study was carried out during 2006-07 at the University of Guyana campus aimed at recycling solid organic waste (Water hyacinth and grass) from urban and rural areas. This recycling was done by employing vermitechnology in established units. This process involved initial biodung composting (pre digestion) of fresh waste followed by vermicomposting. The study concentrated on organic waste such as grass clippings, water hyacinth, cattle manure which was composted using vermitechnology within sixty days to obtain vermicompost. The temperature was monitored daily from the start of biodung composting until the transfer to the vermicomposting tanks. A standard nutrient status of vermicompost with reference to pH, electric conductivity, organic carbon and Nitrogen, Potassium and Phosphorus, was recorded. Potential status of vermicompost as bio fertilizer generated from solid organic waste was assessed for use in Guyana.

The vermitechnology units were established at University of Guyana campus. Chemical analysis of the vermicompost was done at the Guyana Sugar Co-operation Central Laboratory, situated at L.B.I., on the East Coast of Demerara. A culture room with three tanks was established, epegeic earthworms were inoculated with paddy straw and cow dung. *Eisenia foetida* were used in the experiment. Biodung composting was carried out according to the following guidelines:

- Cow dung slurry was made by adding water to cow dung in a ratio 6:3 and stirring mixture
- Cow dung slurry was added layer after layer to the organic materials which were soaked with water
- The heaps were then covered with tarpaulin for thirty days after an initial temperature was taken
- The layers were turned every ten days
- The temperatures were recorded every three days from the time of setting up the bio dung units

Three of the vermicomposting units were constructed with cement, each having dimensions of 5×2.5 feet for bulk production of vermicompost from pre digested organic matter. Zinc shed was constructed above the units for shade. Each vermicomposting units, 1, 2 and 3 comprised of several layers. The first layer starting from the bottom was packed with 2- 3 inches of pebbles and broken bricks the second layer sand, the third had 3 inches of soil. In the fourth layer cattle dung was added and here the earthworms were inoculated, 100-200 earthworms per square meter of vermibed. The pre digested (bio dung), grass, water hyacinth, water hyacinth+grass, were added to vermi units, 1, 2 and 3, respectively. This was followed by a fifth layer of the pre digested (bio dung) organic waste. The final layer acted as a mulch to prevent evaporation. This comprised of grass and dry leaves. The surfaces of the entire vermin pits were covered with tarpaulin which were kept moist by spraying water daily. When all the organic matter was converted to vermicompost in 60 days, it was harvested. Watering was stopped for a week so that the earth worms can move down. The vermi compost after been harvested was sieved through a 3 mm sieve. In order to assess the physicochemical changes during the process, samples were taken from each unit every 10-12 days after the pre digested matter was added.

The physico-chemical analysis of Vermicompost and raw organic matter was carried out according to standard guidelines (Homer, 2003). The samples were then taken and placed to air-dry and then ground for chemical analysis, together with the raw materials (Water hyacinth, grass and a mixture of the two) using standard procedure for the following (pH, EC, Organic carbon, Total kjeldahl nitrogen, Available phosphate, Potash).

RESULTS AND DISCUSSION

Table 1 indicates the treatments used in process of vermicomposting. Table 2 indicated that the maximum productivity in UniT3 (T3) in which the organic waste was in the form of water hyacinth+grass clippings. This is due to greater earthworm activity in (T3) and their preferred palatability of mixed organic waste during the processes of vermicomposting. The mass of the organic material transferred to vermitech unit differed significantly from the mass of vermicompost harvested. The ingested organic material is macerated mixed with ingested soil material passed through the gut and is excreted as casts, with most of it very little changed chemically but finely ground (Ismail, 1997, 2005; Ansari, 2011a, b).

Partial biodung composting in T2 and T3 was carried out for period of 3 weeks and transferred to respective vermicomposting units whereas in T1 was continued to 6 weeks. The temperature study showed that there were two peak rise of temperature during partial biodung composting in

Table 1: Composition of vermicomposting units

Units	T1	T2	T3
Composition	Grass	Water hyacinth	Grass+water hyacinth

Table 2: Harvest data (Vermicompost)

Units	T1	T2	T3
Initial mass (kg)	230	210	105
Transfer to vermitech unit (kg)	120	120	80
Conversion rate (%)	52.17	57.14	76.19
Harvested vermicompost (kg)	60	65	48
Dried vermicompost (kg) with 40% moisture	38	41	32
Productivity of vermicompost (%)	31.67	34.17	40.00

T1 where as single peak in T2 and T3 (Table 3). The partial biodung compost obtained served as a good organic material for the earthworms to recycle and produce vermicompost. The temperature increase brings about killing of harmful microbes. The process of biodung composting involves partially aerobic and partially anaerobic process. This reduces the bulk of organic waste to one third of the volume. The cattle dung solution serves the purpose of providing inoculum of microbes which carry out degradation of organic waste. During the process of biodung composting, mesophilic flora predominates with their metabolic activity resulting in the increase in temperature of the organic waste. They are replaced by thermophilic organisms which survive at temperatures greater than 45°C to facilitate composting. When the temperature falls, mesophilics become active again. The changes in the microflora like bacteria, actinomycetes and fungi during composting have been well studied (Ansari and Ismail, 2001a; Ansari, 2007, 2011a, b).

Temperature was also observed during the process of vermicomposting in the 3 vermicomposting units. The temperature study showed that fluctuation was restricted to ±2.34 (T1), ±0.73 (T2) and ±0.83 (T3) (Table 4).

The initial materials water hyacinth (T2), mixture of water hyacinth and grass (T3) were initially at a neutral pH with the exception of grass (T1) which was extremely mildly acidic, when they were added to the vermicompost units (Table 5) The pH for all fluctuated between 5 and 8 until it was almost neutral on the day sixty, when the compost was harvested. In T3 the percentage change in pH is minimal due to the moisture content of the water hyacinth thus the

Table 3: Temperature (°C) changes during biodung Composting for transfer to vermicomposting

Week	T1	T2	T3
1	31.5	26.5	25
2	43.5	42	39
3	37.0	36	36.5
4	29.5	Transfer	Transfer
5	37.5	-	-
6	33.25	-	-

Table 4: Temperature (°C) changes during the period of vermicomposting

Week	T1	T2	T3
1	31.6	28.5	27.5
2	31.5	28.0	26.0
3	27.5	28.0	28.0
4	28.5	27.0	26.0
5	26.0	27.0	27.0
6	26.0	26.0	27.0
7	27.5	27.0	27.0
8	27.5	27.0	27.0

Table 5: pH changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	%Increase
T1	6	6.86	6.98	6.47	6.57	6.44	6.7	11.70
T2	7	5.68	6.34	6.49	8.00	7.18	7.02	0.29
T3	7	5.24	5.83	6.36	6.69	6.86	6.72	-0.40

- Indicate decrease

Table 6: Electrical conductivity (μs/cm) changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	% Decrease
T1	11.21	13.15	5.2	4.91	4.65	3.65	6.58	-41.3
T2	19.62	6.6	2.68	2.23	21.3	8.2	5.7	-70.4
T3	26.1	8.45	4.62	2.08	8	6.65	7.03	-73.1

Table 7: Organic carbon (%) changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	% Decrease
T1	44.2	38.54	35.6	44.2	30.1	32.3	24.8	-43.9
T2	26	20.6	16.7	20.9	19.2	19.7	17.6	-32.2
T3	34.36	22.1	26.6	25.7	17.03	16.4	13.17	-61.7

water released tends to neutralize the pH of the vermicompost. Generally in all the units there was a temporary rise in pH. Earthworms contribute several nutrients in the form of Nitrogenous wastes. Ammonia which forms a large portion of the nitrogenous matter excreted by earth worms may cause a temporary rise in pH (Ismail, 1997, 2005; Edwards and Bohlen, 1996). The pH regulate the rate of dissolution of substances thus, absorption. Soil pH is one of the most important soil properties that affect the availability of nutrients. Macronutrients tend to be less available in soils with low pH and micronutrients tend to be less available in soils with high pH (Edwards and Arancon, 2004). Thus, it is necessary for the compost to have an ideal pH when added to the soils so as to promote absorption of nutrients (Suthar, 2007).

The Electrical conductivity for T2 and T3, decreased steadily up to day thirty and increased sharply on day forty, followed by a gradual decrease. A similar pattern was observed for T1 but there was an initial increase in EC, followed by a steady decrease. The percent change for T2 and T3 differed slightly but there was a significant percent change for T1 (Table 6). Generally there was a significant decrease in EC of the initial materials as the vermicomposting process proceeded, until a lower EC was attained, which is ideal for plant growth. With a low EC the organic fertilizers release the mineral salts slowly, which is sufficient for plant growth (Ansari and Sukhraj, 2010; Ansari and Jaikishun, 2010).

There was decrease in organic carbon for all three units with gradual decrease at later stage of vermicomposting process. A decrease in carbon is an indicator of enhanced decomposition (Stoffella and Kahn, 2001; Kaviraj and Satyawati, 2003; Agarwal *et al.*, 2011; Kumar and Shweta, 2011). This also explains why the percent changes were so large for T1, T2 and T3 (Table 7). The significant percentage change indicated that earthworms accelerated the decomposition of the organic matter. Carbon is needed by the plants because it forms the basis for energy source for the composting process. Carbon is a major component of organic molecules, which are the building blocks of all organisms (Ismail, 2005; Ansari and Jaikishun, 2010).

There was a sharp increase of nitrogen in T1 and T3 followed by a decrease whereas there was decrease in nitrogen percentage in T2 (Table 8). This high level of nitrogen during the process of vermicomposting is probably contributed by earthworms through excretion of ammonia along with reduction of organic waste to nitrogen component. The significant reduction in the percentage

Nitrogen is probably due to NH3 volatilization, incorporation into earthworm tissues and leaching into the bedding material. This can also account for the significant percent change in T3. In T1 and T2 there was a negative percent change which was probably as a result of microbial utilization. In T2 there was a decrease during the first twenty days, a small increase for the next ten days, followed by a fluctuating pattern.

The general trend of T1, T2 and T3 (Table 9) shows a decline in Carbon nitrogen ratio during the process of litter break down and decomposition, the ratio of C: N is progressively brought down, especially through feeding by earth worms to levels when nitrogen can be directly taken up by plants (Ismail, 1997). The Nitrogen gets mineralized and is shifted to nucleic acids (Ismail, 2005) ammonia, urea and nitrates; and the carbon is used for respiration by the microbes. The net result is the lowering of the C/N ratio during the decomposition process.

The phosphorus content generally increased significantly during the process (Table 10). There was a fluctuating pattern in percent changes observed for Phosphorus. The general rise in phosphate level from initial materials during the process of vermicomposting is probably due to mobilization and mineralization and mobilization of phosphorus due to bacterial and fecal phosphatase activity of earthworms (Ansari and Ismail, 2008a). The percent change was significantly high in all three units, because earth worms play a role in the release of phosphates.

There was a fluctuating change in percentage potassium observed during the vermicomposting process in units T1, T2 and T3 but at the end of the sixty day period a generally increase was observed (Table 11). Potassium forms part of the micronutrient that is boosted by the presence of earthworm activity on organic matter (Kale, 1998; Ansari and Ismail, 2001a, b). Organic fertilizers contain the second largest amount of potassium but these are release at a slow rate in the soil, thus

Table 8: Nitrogen (%) changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	% Increase
T1	1.6	2.43	2.88	2.49	2.14	1.99	1.49	-6.8
T2	2.74	1.86	1.8	1.86	1.22	1.92	1.59	-41.9
T3	1.1	1.83	2.05	1.64	1.88	1.92	1.38	25.5

- Indicate decrease

Table 9: C: N ratio changes during composting process (60 Days)

	Days						
Units	1	10	20	30	40	50	60
T1	27.6	16.4	12.36	17.75	14.1	16.23	16.6
T2	9.49	11.1	9.2	11.2	15.73	10.26	11.1
T3	31.2	12.1	12.98	15.67	9.1	8.5	9.54

Table 10: Phosphates (%) changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	% Increase
T1	0.178	0.322	0.337	0.303	0.266	0.289	0.533	199.4
T2	0.218	0.298	0.226	0.544	0.464	0.506	0.435	99.5
T3	0.274	0.5	0.21	0.219	0.312	0.271	0.327	19.3

Table 11: Potash (%) changes during composting process (60 Days)

	Days							
Units	1	10	20	30	40	50	60	% Increase
T1	1.45	2.03	1.398	1.299	1.346	1.238	1.706	17.60
T2	1.31	1.02	0.95	0.81	2.64	1.85	1.622	23.82
T3	1.37	1.154	1.127	1.017	1.725	1.62	1.76	28.47

Table 12: ANOVA (Two-factor without replication)

	pH		E.C		O.C	
Parameter	F	Fcrit	F	Fcrit	F	Fcrit
(Units)	1.057064	3.885294	0.482963	3.885294	39.28112	3.885294
Changes (day 1-60)	1.403614	2.99612	3.694872	2.99612	7.031721	2.996120

Table 13: ANOVA (Two-factor without replication)

	N		P		K	
Parameter	F	F crit	F	F crit	F	F crit
Units	1.903015	3.885294	1.0101664	3.885294	0.111551	3.885294
Changes (day 1-60)	0.880498	2.99612	1.245663	2.99612	1.718485	2.996120

preventing wastage by being washed away (Ansari and Ismail, 2008a, b; Jayakumar *et al.*, 2011). This also accounts for the significant percent change in all three units.

Based on the Anova test (Table 12, 13) the changes in total organic carbon and EC was significant gradual change during the sixty day period in the individual units for the vermicomposting of grass (T1), water hyacinth, (T2), a mixture of water hyacinth and grass (T3). The difference in total organic carbon between T1, T2 and T3 were also significant indicating the effect of earthworms (*Eisenia foetida*) on the process of decomposition (vermicomposting) The changes were insignificant for the pH, Phosphorus., Potassium and Nitrogen.

CONCLUSION

This study revealed that the water hyacinth and grass clippings which are all organic matter can be efficiently utalised by earthworms to produce vermicompost. Compost harvested from all three units, (T1, T2, T3,) lacked none of the essential nutrients tested for and were present in adequate amounts. Thus, one can recognize that using water hyacinth and grass produce very nutritious biofertilizers. The quantity of any nutrient does not remain constant through out the process; their levels fluctuated until they reach an ideal level that would promote plant growth. The Harvested compost of T1, T2 and T3 all had nearly the same quantity of nutrients tested for, with the exception of Phosphorus and Carbon which differed somewhat. This technology can be successfully implemented in Guyana to solve the problem of organic solid waste management.

REFERENCES

Agarwal, P.K., D.K. Choudhary, A. Prakash and B.N. Johri, 2011. Bacterial diversity in a bagasse-based compost prepared for the cultivation of edible mushrooms *Agaricus bisporus*. J. Agric. Technol., 7: 2109-2117.

Ansari, A.A. and S.A. Ismail, 2001a. A case study on organic farming in Uttar Pradesh. J. Soil Biol. Ecol., 27: 25-27.

Ansari, A.A. and S.A. Ismail, 2001b. Vermitechnology in organic solid waste management. J. Soil Biol. Ecol., 21: 21-24.

Ansari, A.A., 2007. Organic Waste-Reduce, Recycle and Management Through Vermitech. Advance Research Series, India.

Ansari, A.A., 2008a. Effect of vermicompost and vermiwash on the productivity of spinach (*Spinacia oleracea*), Onion (*Allium cepa*) and Potato (*Solanum tuberosum*). World J. Agric. Sci., 4: 554-557.

Ansari, A.A., 2008b. Effect of vermicompost on the productivity of potato (*Solanum tuberosum*), spinach (*Spinach oleracea*) and turnip (*Brassica campestris*). World J. Agric. Sci., 4: 333-336.

Ansari, A.A., 2008c. Soil profile studies during bioremediation of sodic soils through the application of organic amendments (Vermiwash, tillage, green manure, mulch, earthworms and vermicompost). World J. Agric. Sci., 4: 550-553.

Ansari, A.A. and S.A. Ismail, 2008a. Paddy cultivation in sodic soils through vermitech. Int. J. Sustainable Crop Prod., 3: 1-4.

Ansari, A.A. and S.A. Ismail, 2008b. Reclamation of sodic soils through vermitechnology. Pak. J. Agric. Res., 21: 92-97.

Ansari, A.A. and K. Sukhraj, 2010. Effect of vermiwash and vermicompost on soil parameters and productivity of okra (*Abelmoschus esculentus*) in Guyana. Afr. J. Agric. Res., 5: 1794-1798.

Ansari, A.A. and S. Jaikishun, 2010. An investigation into the vermicomposting of sugarcane bagasse and rice straw and its subsequent utilization in the cultivation of *Phaseolus vulgaris* L. in Guyana. Am. Eurasian J. Agric Environ. Sci., 8: 666-671.

Ansari, A.A., 2011a. Vermitech: An innovation in organic solid waste management. J. Sustainable Dev. Environ. Prot., 1: 107-113.

Ansari, A.A., 2011b. Worm powered environmental biotechnology in organic waste management. Int. J. Soil Sci., 6: 25-30.

Edwards, C.A. and P.J. Bohlen, 1996. Biology and Ecology of Earthworms. 3rd Edn., Chapman and Hall, London, ISBN: 0412561603, pp: 426.

Edwards, C.A., 2004. The Use of Earthworms in the Breakdown and Management of Organic Wastes. CRC Press, Florida, USA.

Edwards, C.A. and N.Q. Arancon, 2004. The Use of Earthworms in the Breakdown of Organic Waste to Produce Vermicomposts and Animal Protein. In: Earthworm Ecology, Edwards, C.A. (Ed.). 2nd Edn., CRC Press, Boca Raton, pp: 345-438.

Homer, F., 2003. Soil Analysis Manuel Central Analytical and Environmental Monitoring Services. Agriculture Research Department, Guyana.

Ismail, S.A., 1997. Vermicology: The Biology of Earthworms. Orient Longman, Hyderabad, Pages: 92.

Ismail, S.A., 2005. The Earthworm Book. Other India Press, Apusa, Goa, pp: 101.

Jayakumar, M., T. Sivakami, D. Ambika and N. Karmegam, 2011. Effect of turkey litter (*Meleagris gallopavo* L.) vermicompost on the growth and yield characteristics of paddy, *Oryza sativa* (ADT-37). Afr. J. Biotechnol., 10: 15295-15304.

Kale, R.D., 1998. Earthworm Cinderella of Organic Farming. Prism Book Pvt. Ltd., Bangalore, India pp: 88.

Kaviraj, S. and S. Satyawati, 2003. Municipal solid management through Vermicomposting employing exotic and local species of earthworms. Bioresour. Technol., 90: 169-173.

Kumar, R. and Shweta, 2011. Removal of pathogens during vermin-stabilization. J. Environ. Sci. Technol., 4: 621-629.

Simpson, A.S. and R.D. Martin, 2001. Studies on vermiculture and organic vegetable production. University of Technology, Jamaica.

Stoffella, P.J. and B.A. Kahn, 2001. Compost Utilization in Horticultural Cropping Systems. Lewis Publishers, Chicago, USA., ISBN: 9781566704601, Pages: 414.

Suthar, S., 2007. Vermicomposting potential of Perionyx sansibaricus (Perrier) in different waste materials. Bioresource Techn., 98: 1231-1237.