Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 4413-4421

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-7 pp. 4413-4421**
Journal homepage: http://www.ijcmas.com

Original Research Article

Performance Evaluation of Grinding Machine Developed For Commercial Manufacturing of Quality Vermicompost

Jitendra Kumar[1], Satish Kumar[2*], Ashok Kumar[2] and Manish Kumar[3]

[1]Mandan Bharti College of Agriculture, Saharsa (Bihar) – 852201, India
[2]Bihar Agricultural College, Sabour, Bhagalpur (Bihar) – 813210, India
[3]Nalanda College of Horticulture, Noorsarai (Nalanda) – 803113, India
**Corresponding author*

A B S T R A C T

Vermicomposting is an agro technique for recycling of non-toxic organic wastes into valuable nutrient source for sustainable food production. It refers to organic manure produced by earthworm. Recent years have witnessed a renewed interest in microbial techniques of composting and Vermicomposting of farm, urban and agro-industrial wastes. It is being increasingly realized that composting is an environment- friendly process to convert a wide variety of into valuable agricultural inputs and in the process minimize their becoming environmental problems. Compost being a balance source of plant nutrients improves physical, chemical and biological properties of soil addition to increased crop yield For vermicomposting it is necessary to develop waste treatment technology of economically accessible & operationally feasible with assured quality product. Manufacturing vermicompost needs lot of manual labor for mixing and grinding of cow dung with straw and other organic waste material, which should be minimized with the help of a mechanical unit. This helps in reducing time, cost and also improving the quality of final product. A mechanical grinding machine has been designed and developed for vermicompost with reduced size of leaf wastes at STEP, IIT Kharagpur. The machine element consists of a motor, gear box, shaft, adjustable blade, bearing, drum and switch and adjustment blade shaft. This machine carried out grinding of all types of dry and moist items. The electric motor operated batch type media mixer has blade type agitators provided on a shaft rotating at 210 rpm for thorough mixing. The mixer has a capacity varying from 250 to 300 Kg per batch and takes 6 minutes for thorough mixing of vermicompost. The grinding machine has capacity of 250 to 300 Kg per batch for moist leaf wastes. The grinding machine was found to be best for 30 Kg dry leaf wastes on operation for six minutes. Vermicompost manufactured from the raw material noted lowest N content (0.8%) for cow dung and that prepared from mixture of Black old tea + Cow dung noted highest N content (3.14%). The Phosphorus content of raw materials varied between 0.25 for Cow dung to 0.96 % for the mixture of Poultry manure (old) and Cow dung in the ratio of 25:75. The pH of raw materials varied between 5.5 for Black (old) Tea to 7.4 for Poultry manure (new). p^H value in case of manufactured vermicompost for all the cases was found between 5.1 for Black (old) Tea and 7.1 for Poultry manure (new). For getting optimal quality of vermicompost temperature and moisture content are ranging between 30-35 ^{0}C and 30-45% on dry weight basis respectively. From the values of grinding machine performance indices it would be concluded that performance of designed grinding machine is satisfactory.

Keywords

Vermicompost, grinding machine, CN ratio, pH, Phoshporus content

Introduction

Lands under intensive human impact are severely affected in the quality of natural resources, such as water and soil; policies of water and soil-conservation are urgently needed. In particular, the level of surface groundwater is decreasing and the water quality is becoming more affected by contamination by effluents from industry and agriculture. In addition, the pressures to sustain modern agricultural systems cause a progressive degradation of soil structure (as a result of soil erosion) and a continued depletion of soil fertility level (as a result of organic matter reduction).

As a consequence, the agricultural lands need, continuously, nutritional substances and water to improve and maintain the agronomic fertility. The treatment of soil with different sources of organic substrates for enhancing soil quality has been reported in numerous papers (*Bastian and Ryan, 1986; Garcia et al., 1992a; 1994*). For example, the use of a particular worm casting (vermicompost) with a good fertilizing value, has recently been proposed in experiments for regeneration of degraded land (*Kale and Bano, 1986; Ceccanti, 1994*). Earthworms have a great ability to consume all organic wastes, reducing their volume by about 50% and expelling the digested materials as castings, which are a useful soil amendment and may be easily stored for agricultural use (*Tomati et al., 1985*).

Vermicomposting has been reported to be a viable, cost-effective and rapid technique for the efficient management of the organic solid wastes (*Hand et al., 1988*). It refers to organic manure produced by earthworm. Recent years have witnessed a renewed interest in microbial techniques of composting and vermicomposting of farm, urban and agro-industrial wastes. It is being increasingly realized that composting is an environment-friendly process to convert a wide variety of wastes into valuable agricultural inputs and in the process minimize their becoming environmental problems (*Shiralipour, et al., 1992*). Composting is an excellent source of humus and plant nutrients resulting in improvement of physical, chemical and biological properties of soil and organic matter status in addition to increasing crop yields (*Ferreras, L. et al., 2006*).

A wide variety of organic products and wastes can be recycled and made into compost. There exists an enormous potential of agricultural, rural and urban wastes in India (*Kaushik et al., 2004*).

The theoretical potential plant nutrient supply by bovine excreta and urine is 3.44, 1.31 and 2.21 million tones of N, P_2O_5, and K_2O respectively (*Gaur, 1992*). The average annual output of crop residues is around 340 million tones of which 50% is used as fodder. Crop residues of rice, wheat, sorghum, pearl millet, maize, sugarcane, and others can contribute nearly 1.68 mt of N, 2.02 mt of P_2O_5 and 5.04 mt of K_2O (*Gaur, 1992*).

The conventional technologies for waste treatment are not economically feasible for small-scale industries prevalent in developing economies due to huge capital investment. It is therefore necessary to search for alternative methods, which are low-cost, easy to handle and better product quality

Manufacturing vermicomposts needs lot of manual labor for mixing and grinding of waste material, which should be minimized with the help of a mechanical unit. This will help in reducing time, cost and also improving the quality of final product. Keeping in view the above facts, a Grinding Machine has been design and developed for commercial manufacturing of quality Vermicompost by composting the different types of organic substrates and quality of vermicompost thus produced.

Materials and Methods

An organic waste grinding machine unit was designed and fabricated for organic waste. It was developed for reducing the use of human labor for mixing and grinding cow dung with straw, with better efficiency. The set up consists of a motor, gear box, shaft, adjustable blade, bearing, drum, and switch and adjustment blade shaft, with the following specification.

Full Capacity: 1200 L

Working Capacity: 1000 L

Capacity: 250-300 kg of mixture

Stable and simple design to achieve endurance performance.

Stirring blades are in good efficiency on mixing.

Stainless steel made tank meets the sanitary requirements.

Easy operation and easy preparation.

Unique design adjustable blades with special angle to cut the mixture.

Design and development of organic waste grinding cum mixing machine unit

The methods of design and fabrication of the setup are discussed assembly wise in the following paragraphs.

Motor: Three-phase AC induction electric motor of capacity 7.5 HP and 1440 RPM was used for power transmission.

Gear Box: Beval gears with 18 and 10 teeth were used to reduce the rotational speed of shaft, on which blades are mounted and rotating inside the drum. The rpm output of the above shaft varied between 400 to 500 rpm.

Adjustable blade shaft: An adjustable shaft was used to connect with the six numbers of stainless steel blades. Power is transmitted to the shaft through gear box assembly, which is connected to the motor. A hard material is used below the shaft to reduce wear and tear in it due to opening and closing at the bottom of the drum. The hard material is made-up of cup type structure, and the bottom end of the shaft is fixed in this cup to reduce any problem in alignment.

Adjustable blade: Four numbers of blades were used to cut the raw material into small pieces. The angle with the horizontal axis is adjustable with the use of coupling arrangement. The blades are connected to the shaft.

Drum: A drum made of MS steel was fixed inside the frame for mixing and cutting the raw material. The diameter of the drum was 122 cm, while overall height was kept as 127 cm. The thickness of the material used to make the drum was 0.4 cm. The bottom of the drum can be opened or closed depending upon the use. During mixing and grinding of the raw material it has to be kept close, while for removing the resultant mix it is opened through a slider gate. The top of the drum is kept closed in such a way that maximum part of the top portion remains close every time, while a little space is kept open for entering of the raw material to be mixed and grinded.

Stand: It is made of 4 mm thick MS iron. The stand was made to support the drum and other accessories. The length of the stand without the bottom support is 224 cm and the height of stand for keeping the motor assembly is 61 cm. The distance between the two adjacent legs is kept constant as 156 cm.

Experimental Procedure

For the experimental purpose 6 types of raw materials were used. The composition of these 6 cases is as below:

Cow dung only (300kg.)

Cow dung + kitchen waste (90kg. +210kg.)

Cow dung + Agriculture waste (90kg. +210kg.)

Cow dung + Tea waste (90kg. +210kg.)

Cow dung +Poultry manure (90kg. +210kg.)

Cow dung +Mixture of Neem cake + Row phosphate and Agriculture waste (90kg. +15kg +15kg +180kg.)

For the different type of organic wastes 5 different bed were selected for experimental purpose.

In which for each bed, 2 replications is taken for the accuracy of measurement of vermicompost and raw quality sample.

Instrument Used

Microkjeldahl Instrument for total N nutrient analysis in raw material and Vermicompost.

Spectrophotometer used for available P nutrient analysis in raw material and Vermicompost.

Flame photometer used for K nutrient analysis in raw material and Vermicompost.

pH meter.

Analysis for N, P and K Values

Analysis for total nitrogen (organic nitrogen) in Vermicompost or nutrient solution.

Analysis for phosphorus and potassium in Vermicompost and nutrient solution

Micro-Kjeldahl distillation apparatus along with 100 ml Kjeldahl flasks, Conical flask and quick delivery 10 ml pipette was used for the analysis of nitrogen.

The Concentrated sulfuric acid and Salt Mixture Mix 250g K_2SO_4 or Na_2SO_4 with 50 g $CuSO_4$, and 5 g metallic selenium were used as reagents.

200 mg of dried sample or 10 ml of liquid sample in a 100 ml Kjeldahl flask was kept and approximately the same weight of salt mixture and 5 ml of concentrated H_2SO_4. was added to it. Thereafter, Kjeldahl flask was placed in digestion chamber to digest the sample. When sample became is clear, it was cooled and then 10 ml of distilled water was added and mixed thoroughly to allow the sample to cool again. There aster N value of the vermicompost was calculated with the help of standard procedure.

Spectrophotometer, flame photometry, 75ml Pyrex test tubes graduated at 50 ml, filter funnels, and Whatman filter papers Nos. 1 and 44 and pH meter was used for the analysis of P and K values of the vermicompost. A mixture containing 750 ml concentrated HNO_3, 150 ml concentrated H_2SO_4, and 300 ml 60 to 62 percent $HClO_4$ was used as reagent.

500 mg of dried, ground, plant material was kept in a conical flask. Thereafter 10 ml of acid mixture was added and conical flask was kept on sand bath at least for 2 hours for digestion. When the sample became clear it was cooled. Then sample extract was filtered thorough an acid washed filter paper in a 100 ml volumetric flask and volume upto 100 ml was made.

Results and Discussion

Performance analysis of grinding cum mixing machine

4 sets of different mixtures of agriculture waste, cow dung and water was tested for checking how much time the machine is taking for reducing the raw material size into small pieces. The composition of mixture and time taken by the developed machine is shown in tabular form as below;

Measurement of N, P, K, pH and CN ratio

Measurement of pH for both vermicompost and raw material was done with the help of pH meter and C: N ratio is simply calculated from dividing the percentage organic carbon to the total N.

Manufacturing vermicompost needs lot of manual labor for mixing and grinding of cow dung with straw and other organic waste material, which should be minimized with the help of a mechanical unit.

This helps in reducing time, cost and also improving the quality of final product.

Fig.1 Design of organic waste grinding machine

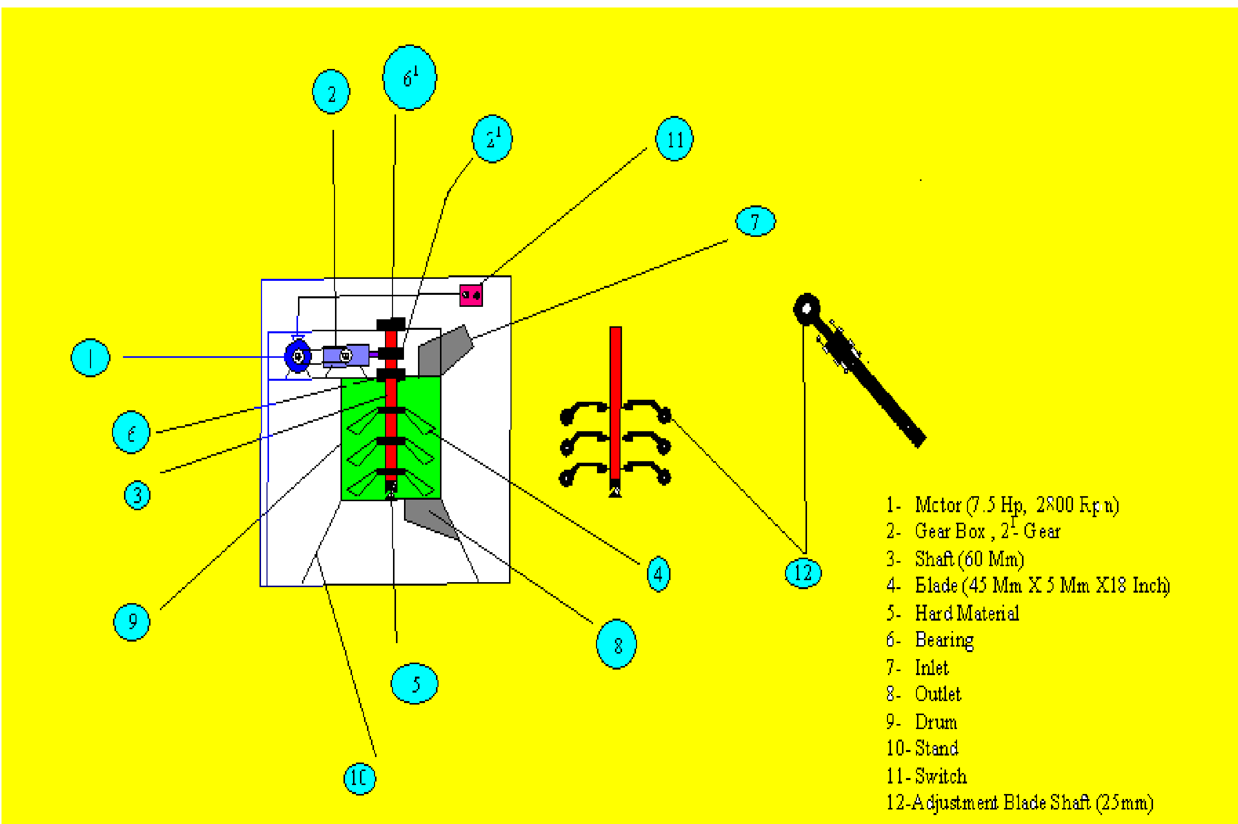

Table.1 Performance analysis of grinding cum mixing machine

Sr. No.	Agriculture waste (kg)	Cow dung (kg)	Water (L)	Time (Min)
1	20	10	20	2
2.	50	15	30	3
3.	70	30	60	5
4.	100	42	85	7

Table.2 Nitrogen (%) value of Row materials& & Vermicompost

Sample	Raw material	Vermicompost
Cow Dung	0.45	0.8
Cow Dung + Agri. Waste	1.43	1.55
Cow Dung + Kitchen Waste	1.56	1.69
Brown (New) Tea	3.41	2.842
Black (old) Tea	3.54	3.88
Semi-solid Tea	1.37	2.54
Brown (New) Tea + CD	2.677	2.842
Black (old) Tea + CD	2.98	3.136
Semi-solid Tea + CD (50:50)	1.47	1.74
Poultry manure (New)	2.548	1.489
Poultry manure (New)25+CD. 75	1.081	1.078
Poultry manure (New)50+CD. 50	1.062	1.058
Poultry manure (old)	2.764	1.698
Poultry manure (old)25+CD. 75	1.697	1.564
Poultry manure (old)50+CD. 50	1.582	1.493

Table.3 Phosphorus (%) value of Row materials& & Vermicompost

Sample	Raw material	Vermicompost
Cow Dung	0.02	0.03
Cow Dung + Agri. Waste	0.04	0.06
Cow Dung + Kitchen Waste	0.09	0.1
Brown (New) Tea	0.176	0.194
Black (old) Tea	0.136	0.168
Semi-solid Tea	0.011	0.184
Brown (New) Tea + CD	0.153	0.212
Black (old) Tea + CD	0.102	0.156
Semi-solid Tea + CD (50:50)	0.052	0.14
Poultry manure (New)	0.889	0.32
Poultry manure (New)25+CD. 75	0.19	0.182
Poultry manure (New)50+CD. 50	0.146	0.134
Poultry manure (old)	0.1	0.184
Poultry manure (old)25+CD. 75	0.96	0.148
Poultry manure (old)50+CD. 50	0.845	0.138

Table.4 Potassium (%) value of Row materials& & Vermicompost

Sample	Raw material	Vermicompost
Cow Dung	0.5	0.87
Cow Dung + Agri. Waste	1.02	1.1
Cow Dung + Kitchen Waste	1.1	1.3
Brown (New) Tea	0.22	0.52
Black (old) Tea	0.36	0.4
Semi-solid Tea	0.083	0.78
Brown (New) Tea + CD	0.25	0.5
Black (old) Tea + CD	0.31	0.49
Semi-solid Tea + CD (50:50)	0.102	0.76
Poultry manure (New)	1.6	1.8
Poultry manure (New)25+CD. 75	0.958	0.98
Poultry manure (New)50+CD. 50	0.738	0.76
Poultry manure (old)	1.24	1.28
Poultry manure (old)25+CD. 75	0.887	0.91
Poultry manure (old)50+CD. 50	0.849	0.92

Table.5 CN ratio of Row materials& & Vermicompost

Sample	Raw material	vermicompost
Cow Dung	7.74	6.53
Brown (New) Tea	4.39	4.75
Black (old) Tea	4.52	3.92
Semi-solid Tea	12.04	5.74
Brown (New) Tea + CD	6.38	5.73
Black (old) Tea + CD	6.07	5.67
Semi-solid Tea + CD (50:50)	12.58	9.36
Poultry manure (New) control	7.1	11.82
Poultry manure (New)+cw (50:50)	7.3	10.2
Poultry manure (New)+cw (25:75)	7.5	10.8
Poultry manure (old) control	5.02	7.4
Poultry manure (Old) +cw(50:50)	6.8	8.1
Poultry manure (Old) +cw(25:75)	7.0	8.9

Table.6 p^H value of Row materials& & Vermicompost

sample	pH	pH
Brown (New) Tea	5.6	5.2
Black (old) Tea	5.5	5.1
Semi-solid Tea	7.1	6.8
Brown (New) Tea + CD	6.4	6.2
Black (old) Tea + CD	6.3	5.8
Semi-solid Tea + CD (50:50)	7.3	6.9
Poultry manure (New)	7.4	7.1
Poultry manure (new) (50:50)	7	6.4
Poultry manure (new) (25:75)	7.1	6.6
Poultry manure (old)	7.2	6.8
Poultry manure (old) (50:50)	6.2	6
Poultry manure (old) (25:75)	6.4	6.2

A mechanical grinding machine has been designed and developed for vermicompost with reduced size of leaf wastes at STEP, IIT kharagpur. The machine element consists of a motor, gear box, shaft, adjustable blade, bearing, drum and switch and adjustment blade shaft. This machine carried out grinding of all types of dry and moist items. The electric motor operated batch type media mixer has blade type agitators provided on a shaft rotating at 210 rpm for thorough mixing. The mixer has a capacity varying from 250 to 300 Kg per batch and takes 6 minutes for thorough mixing of vermicompost. The grinding machine has capacity of 250 to 300 Kg per batch for moist leaf wastes. The grinding machine was found to be best for 30 Kg dry leaf wastes on operation for six minutes.

Vermicompost manufactured from the raw material noted lowest N content (0.8%) for cow dung and that prepared from mixture of Black old tea + Cow dung noted highest N content (3.14%). The Phosphorus content of raw materials varied between 0.25 for Cow dung to 0.96 % for the mixture of Poultry manure (old) and Cow dung in the ratio of 25:75. Phoshporus content in case of manufactured vermicompost for all the cases was found between 0.03 for Cow dung and 0.32 for Poultry manure (new). The Potassium content of raw materials varied between 0.25 for Brown (New) Tea + Cow dung to 1.6% for Poultry manure (new). Potassium content in for Black (old) Tea and 1.8 for Poultry manure (new). The minimum value of CN ratio was found as 4.39 for Brown (new) Tea, while maximum value of CN ratio was found as 12.58 for the mixture of Semi-solid Tea + CD in the ratio of 50:50. The pH of raw materials varied between 5.5 for Black (old) Tea to 7.4 for Poultry manure (new). PH value in case of manufactured vermicompost for all the cases was found between 5.1 for Black (old) Tea and 7.1 for Poultry manure (new). For getting optimal quality of vermicompost temperature and moisture content are ranging between 30-350C and 30-45% on dry weight basis respectively. From the values of grinding machine performance indices it would be concluded that performance of designed grinding machine is satisfactory.

References

Anonymous. Recycling wastes to the land. In Food, Fuel and Fertilizer from Organic Wastes. *National Academy Press*, Washington DC, 93-114, 1981.

Bastian, R. K. & Ryan, J. A., Design and management of successful land application system. In *Utilization, Treatment and Disposal of Waste on Land*, pp. 217-234. Soil Science Society of America, Madison, USA. 1986.

Ferreras, L., Gomez, E., Toresani, S., Firpo, I. and Rotondo, R. Effect of organic amendments on some physical, chemical and biological properties in a horticultural soil. *Bioresource Technology*, 97(4): 635-640, 2006.

Garcia, C., Hernandez, T. & Costa, F. (1992a). Variation in some chemical parameters and organic matter in soils regenerated by the addition of municipal solid waste. *Environ. Mgmt*, 16: 763-768. 1992a.

Garcia, C., Hernandez, T., Costa, F. & Ceccanti, B., Biochemical parameters in soils regenerated by the addition of organic wastes. *Waste Mgmt Research*, 12, 457-466. 1994.

Gaur A.C., Sadasivam K.V. Theory and practical considerations of composting organic wastes. *In organic in Soil Health and Crop Production*. 1-22, 1992.

Hand, P., Hayes, W.A., Frankland, J.C.,

Satchell, J.E. 1988. The vermicomposting of cow slurry. In: *Earthworms in Waste and Environmental Management*, pp. 49–63.

Harris, R.C., Knox, K., Walker, N., 1990. Strategies for the development of sustainable land fill design. In: *IWM Proceedin*: 26–29, 1990.

Kale, R. D. & Bano, K., Field trials with vermicompost (Vee Comp. E. 83. UAS) an organic fertilizer. In *Proc. of the National Seminar on Organic Waste Utilisation Vermicompost*, *Part B:* Verms and Vermicompost, ed. M. C. Dass, B. K. Senapati & P, C. Mishra, pp. 151-157, Sri. Artatrana Ront, Burla. 1986.

Kaushik, P. and Garg, V.K. Dynamics of biological and chemical parameters during vermicomposting of solid textile mill sludge mixed with cow dung and agricultural residues, *Bioresource Technology*. 94(2):203–209, 2004.

Logsdson, G., Worldwide progress in vermicomposting, *Biocycle* 35:63–65, 1994.

Marinari, S., Masciandaro, G., Ceccanti, B., and Grego, S., Influence of organic and mineral fertilizers on soil biological and physical properties, *Bioresource Technology*.72:9–17, 2000.

Raymond, C.L., Martein Jr., J.H. and Neuhauser, E. F., Stabilization of liquid municipal sludge using earthworms, *Earthworms in Waste and in Environment Management*, SPB Academic Publishing, The Netherlands :95–110,1988.

Shiralipour, A., Mc Connell, W. and Smith, W.H. Physical and chemical properties of soil as affected by municipal solid waste compost application, *Biomass Bioenergy*, 3:195–211, 1992.

Tomati, U., Grappelli, A. & Galli, E., Soil microorganisms and long-term fertility. In Long-Term Effects of Sewage Sludge and Farm Slurries Applications, ed. J. H. Williams, G. Guidi & P. l'Hermite, pp. 14-22. *Elsevier Applied Science*, London, UK. 1985.