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Utilization of different horticultural waste materials for vermicomposting by using *Eisenia fetida* in Mandhana Kanpur-UP, India

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Abstract
This experiment entitled "Utilization of different Horticultural waste materials for vermicomposting by using *Eisenia fetida*" was carried out form 15th Dec 2020 to 15th May 2021 investigate response of *Eisenia fetida* on different horticultural waste materials to obtain quality compost. The experiment was carried out in Randomized Complete Block Design (RCBD) with five treatments and three replication. One kg of each horticultural waste materials i.e. Parthenium leaves (Parthenium hysterophorus), Justicia leaves (*Justicia adhatoda*), Banana stem and Ashok leaves (*Polyalthia longifolia*) were mixed with cow dung at the ratio of 1:1.These mixtures and the similar weight of cow dung were considered as treatments. Each experimental units were inoculated with 200 nos. of earthworms *(Eisenia fetida)* for vermicomposting. Multiplication ratio, cocoons number, vermicompost yield, vermicompost maturation period and nitrogen content were investigated and analyzed with Duncan's Multiple Range Test (DMRT) at 5% level of significance. The multiplication ratio of earthworm was found higher on Justicia leaves (1.06) and lower on cow dung (0.90). Similarly, cocoon production was found significantly higher on the Justicia leaves (272) and lower on Banana stem (53.33). The vermin compost yield was found significantly higher on the cow dung (1.78 kg) and lower on Justicia leaves (0.65 kg) from 2 kg substrate. At first, cow dung matured in 76 days whereas Ashok leaves matured lastly in 108 days on ward. The vermicompost produced from Ashok leaves mix recorded significantly higher (3.09%) nitrogen content whereas cow dung (1.93%) recorded the least. Among these five feeding materials, Justicia leaves was found most effective and suitable for obtaining the higher population of the earthworm. Additionally, cow dung was found effective for quick vermicompost maturation. This experiment proves that these horticultural waste materials can be used and managed effectively by vermicomposting.

Keywords: *Eisenia fetida*, horticultural waste, cow dung, vermicompost

1. Introduction
These years much attention was paid to manage different organic waste resources at low-input as well as eco-friendly basis. Vermicomposting is one of the ways to reduce this organic waste and was practically used all over the world. Vermes is Latin word for worms and vermicomposting is essentially composting with worms (Ghatnekar *et al.*, 1998) [19]. In nature, all organic matter eventually decomposes. But in vermicomposting, the worm speed up the process of decomposition and get a richer end product called "worm castings". On the other hand vermicomposting is a process of utilizing earthworms and it is an eco-biotechnological process that transforms energy rich and complex organic substances into a stabilized humus-like product (Benitez *et al.*, 1999) [3].

Vermicomposting differs from conventional composting in several ways (Gandhi *et al.* 1997) [17]. It is a simple and low cost, an environment friendly biotechnology system for the processing or treatment of organic wastes (Hand *et al.*, 1988), in which certain species of earthworms are used to accelerate the breakdown of organic matter and stabilization of soil aggregates (Dindal, 1985) [8] to enhance the process of conversion of waste to a useful byproduct. Since it contains water-soluble nutrients, vermicompost is an excellent, nutrient-rich organic fertilizer and soil conditioner (Ravichandran *et al.* 2001) [1].

The earthworm particularly red worm (Eisenia fetida) is used as the most suitable species for vermicomposting and it is widely used for the vermicomposting all over the world. Eisenia fetida has a wider tolerance for temperature than other species. It tolerates as high as 42^0C and as low as 5 ^{0}C. They feed on wide range of solid waste and consume organic material equal to their body weight per day (Reinecke *et al.*, 1992) [32]. The growth and reproduction of Eisenia fetida is also faster than other species of earthworms (Saini *et al.*, 2010) [35]. Also, types or nature of feeding materials influences the growth of earthworms, duration for digestion and

nutrient content of vermicompost. Earthworm cast amendment has been shown to increase plant dry weight (Edwards, 1995) [14] and plant N uptake (Tomati, 1994). Burrowing and casting activities of earthworms contribute to the activity of soil microorganisms (Edwards, 1995) [14] and Nutrient enriched earthworm casts are good media supporting microbial growth (Lee, 1985) [23]. Siddique *et al.* (2005) reported that Cattle manure is an excellent food source for earthworm.

Some of the research based problem was, also, excessive use of chemical fertilizers become one of the main problem. Chemical fertilizers have hazardous effect and became main reason for decreasing soil fertility as well as environment degradation. Environmental degradation is consider as a major threat confronting the world, and the rampant use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of carbon dioxide (CO2) and contamination of water resources. It leads to loss of soil fertility due to imbalanced use of fertilizers that was adversely impacted agricultural productivity and causes soil degradation. (Aveyard 1988, Wani and Lee 1992, Wani *et al.* 1995) [2]. Microorganisms are important biological organisms helping nature to maintain nutrient flows from one system to another and also minimize environmental degradation. The over use of the chemical fertilizers create disturbance on the soil microbial activities and deplete soil quality (Wani, 2002). As the results of civilization and urbanization, people interest on gardening and landscaping also amassing and demanding. Hence, from the garden daily large amount of organic residues are attaining which used to chuck on dumping site as useless and unwanted products. Such large quantities of organic wastes generated also pose a problem for safe disposal. Wastages become the emerging issue and the major source of various types of pollution. Pollution by waste generation has become a global threat and its environmentally friendly disposal or treatment system is a prime need (Padma *et al.*, 2002; Kale *et al.*, 1982; Daniel *et al.*, 1999; Garg and Kaushik, 2005) [26].

2. Materials and Method

The detail of the experimental material, techniques and procedure during the experiment entitled "Utilization of Different Horticultural Waste Material for Vermicomposting by using Eisenia. Fetida" are described in this chapter. The details of activities under this title are as follows:

2.1 Description of the experiment

The Experiment consists of five treatments with three replications in Randomized complete block design (RCBD). The treatments used were Parthenium leaves, Justicia leaves, Banana stems, Ashok leaves, cow dung and mixed with cow dung at the rate of 1:1 ratio. The five treatments were carried out in fifteen Plastic Bucket i.e. each treatment was replicated three times for which three plastic bucket was used as a container for feeding the earthworms.

Brief information regarding the location of experiment, duration of the experiment, climatic condition, soil characteristics and experimental designs are as mentioned below.

2.2 Geographical location of the experimental site

The experimental site was horticultural field of Rama University, Mandhana, Kanpur, Uttar Pradesh, India. Geographically it is located between 26.35°N 80.09°E **Coordinates:** 26.35°N 80.09°E. The altitude of the site ranges from130.00m/426.51ftabove sea level.

2.3 Duration of the experiment

The experiment was conducted for five month form 15th Dec 2020 to 15th May.

2.4 Climate of site

The experiment area is situated in the tropical climate of tarai eco-zone. It is characterized by four distinct seasons: the rainy season (May to July), the autumn (August to October), the winter (November to January) and the spring season (February to April). The maximum winter temperature rises to 27 ºC. The hottest period of the year is April to July. June-July receives the highest amount of rainfall (up to 150 mm in 24 hours). Humidity starts rising from May and reaches to 100% in December and January.

The meteorological data obtained for the study period was taken from thermo hygrometer installed at experimental site.

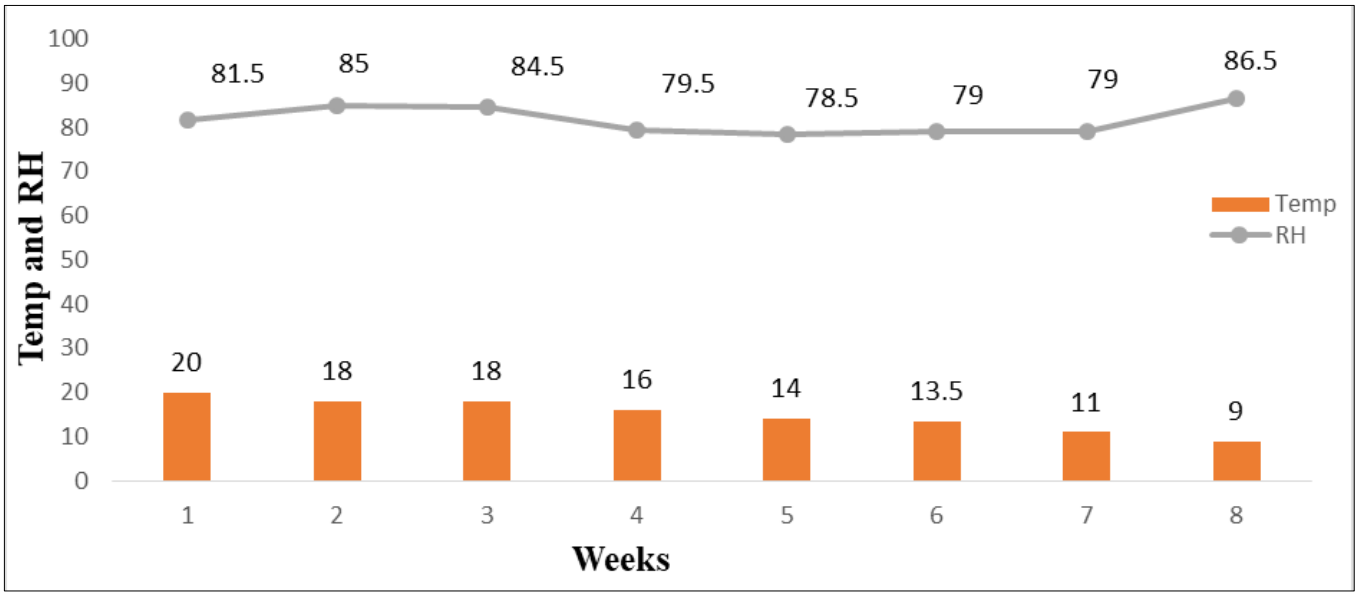

Fig 1: Temperature and relative humidity recorded during the experimental period

2.5 Experimental design and Layout
The experiment was conducted on Randomized Complete Block Design (RCBD) in the shade house. There were five treatment each having three replication. Hence, each treatment include the different feeding materials for earthworm but applied at the equal proximate rate. There were five rows and 3 column.

2.6 Details for Preparation of Vermi-bed
Horticultural wastages were first collected and then weighted and chopped in required size. They were dried under shade for 7 days and 8- 10 days old cow dung was used. Same size of bucket with pierced concentric hole in middle were made for aeration and for maintaining the moisture in vermicompost. Proper size of jute sack were cut as required, wetted with water and fitted inside the bottom of the bucket. Chopped rice straw was taken, weighted, soaked in water as required and spread over fitted jute sack inside bucket. Feeding materials and cow-dung were kept side by side at the 1:1 ratio was served as bedding as well as food for the earthworms. Watering was done when required for pre-composting, microbial degradation and softening of waste. Same age having clitellate region developed Eisenia. Fetida were stocked in each experimental bucket containing 2 kg of substrate material. The moisture level was maintained around 60-80% and throughout the study period by periodic sprinkling of adequate quantity of tape water. To prevent the moisture loss, the experimental containers were covered with jute bags, containers were kept in shady place.

2.7 Substrate/wastes used in feeding earthworm
The substrates used for feeding the earthworm were horticulture waste available nearby or within garden area. The wastages were collected from the periphery of the University, Mandhana, Kanpur.

2.8 Amount of Feeding Materials
The total amount of feeding materials used were 15kg that were brought each having 3kg. They were applied only single time and1kg per each bucket with cow dung at the rate of 1:1 ratio. Chopped rice-straw of about 500gm was kept as bedding material in each experimental bucket.

2.9 Earthworm used in vermicomposting
Only one earthworm species i.e. *Eisenia fetida* was inoculated for vermicomposting in all the experimental buckets. In each treatment and replication 200 earthworm per bed were inoculated. 11: 200 *Eisenia fetida* was inoculated in Experimental Buckets.

2.10 Aeration
The vermicomposting material i.e. Garden wastages were turned up and down and mixed manually at regular interval in order to maintain the aeration which assist in proper functioning of the earthworms.

2.11 Collection of vermicompost and earthworm
After the wastage were consumed by earthworm and were changed into cast, the vermicompost, earthworm and their cocoon were separated by counting.

2.12 Observational parameters
The observations were taken from each treatment and its replications. Following parameters were taken at the time of data collection.

a. Vermicompost produced
The vermicompost produced from different feeding materials were separated from earthworm and then dried in shade for a day. Then the vermicompost were weighed with the help of electronic balance.

b. Earthworm Collected
The earthworms that were separated from vermicompost were spread over polythene film and counted manually.

c. Cocoon collected
The cocoon produced were separated from vermicompost and counted manually.

d. Nutrient content of vermicompost produced
The total nitrogen content of vermi-compost produced was analysed on laboratory.

e. Duration required for the digestion of the feeding materials into vermicompost
Earthworm required 76 to 108 days onwards for the digestion of the feeding materials. The time period required for decomposition to the preparation of final cast was noted. Cow dung was prepared as cast at first. Similarly, Parthenium leaves, Justicia leaves, Banana stem and finally Ashok leaves.

3. Result and Discussion
The results and discussion of the research entitled "Utilization of Different Horticultural waste materials for vermicomposting by using *Eisenia fetida*" is presented in this chapter with the necessary tables and figures wherever possible. The results were analyzed and interpreted with supporting evidences.

3.1 Population
3.1.1 Multiplication ratio of earthworm under different feeding Materials
Multiplication ratio of earthworm population due to different treatments is presented on Table 1. Multiplication ratio showed non-significant result among treatments. Densities of earthworm was higher in Justicia which was followed by banana stem and ashok leaves which have identical value. High mortality was found in cow dung. Hence least earthworm density was recorded in cow dung with negative multiplication ratio. The high mortality was found in cow dung which may be attributed to poor aerated condition for earthworm. This is due to the higher moisture content and poor aeration for worm growth. As Justicia is taken as medicinal plant (Dhankar S, *et al.*, 2011) it might have certain compounds that might favour the multiplication of earthworm which need to be studied in further studies.
For the supportive references related to our study, Parthenium hysterophorus were found superior with regards to increase in earthworm population compared to other weeds like Achyranthusaspera, Pennisetum sp., and Euphorbia geniculata (Biradar and Patil, 2001) [4]. Tripathi *et al.*, 2015 [42] reported that the multiplication of worm was highest in cow dung followed by mixture, banana stem, and grasses and at least in cabbage. Earthworm when introduced into organic waste shows an increased growth rate and reproduction activity (Suthar and Singh, 2008) [40]. It is very obvious that the multiplication of earthworms depends directly on quality and

nutrient content of feeding materials fed to earthworms.

Table 1: Multiplication ratio of earthworm population under different treatments

Treatments	Multiplication ratio
T1 (Parthenium leaves)	1.003
T2 (Justicia leaves)	1.06
T3 (Banana stem)	1.02
T4 (Ashok leaves)	1.02
T5 (Cow dung)	0.90
Mean	1.04
LSD $_{0.05}$	NS
SEM(±)	1.73
CV %	12.75

Means followed by common letter (s) within column are non – significantly different based on DMRT at P = 0.05. NS: Non-significant. SEM: Standard Error of Mean. CV: Coefficient of Variation

3.1.2 Production of Cocoon

Production of cocoon among different treatment is presented on Table 2. Number of cocoon shows significant results. No of cocoon was reported maximum on Justicia leaves (272) whereas the result was statistically similar to Ashok leaves (256.67). Justicia leaves and ashok leaves were at par with cow dung. Banana stem exhibited less number of cocoon (53.33). Cocoon numbers is directly co-related to the multiplication ratio of earthworm. As, the multiplication ratio was higher in Justicia which influenced the nos. of cocoon directly. Here, the result was not satisfied with the lowest multiplication ratio of earthworm with the nos. of cocoon in cow dung.

As, we discussed earlier higher moisture content of the cow dung affect the multiplication ratio negatively but the moisture might escaped by the time and the eggs laying might be occurred lately. Edwards *et al.*, (1998) [15] concluded that rate of cocoon production must be related to the quality of the waste material used, which is one of the important factors in determining onset of cocoon production and similarly temperature up to 30^0C and moisture content 60-75% was considered good for worm growth and production (Reinecke, A., & Venter, J., 1987) [33]. Suthar (2005) [38] summarized that the difference in cocoon production could be due to the variation in quality of the substrate.

Table 2: Number of cocoon production on different treatments

Treatments	No. of cocoon
T1 (Parthenium leaves)	151.67
T2 (Justicia leaves)	272
T3(Banana stem)	53.33
T4 (Ashok leaves)	256.67
T5(Cow dung)	224.3
Mean	191.6
LSD 0.05	91.05**
SEM(±)	23.56
CV %	25.24

Means followed by common letter (s) within column are non – significantly different based on DMRT at P = 0.05. NS: Non-significant. SEm: Standard Error of Mean. CV: Coefficient of Variation

3.1.3 Amount of vermicompost produced

The effect of feeding materials on the vermicompost yield is presented in table No. 3. Vermicompost yield was also varied significantly with the type of feeding materials. Yield was significantly higher in cow dung (1.34 kg) followed by Ashok leaves (1.78 kg). The lowest yield was recorded in Justicia (0.65 kg).

Similar results also found on Tripathi et.al (2015) [42] that yield was significantly higher in cow dung followed by grass. Other substrates fed have to be decomposed which might be results on more weight loss whereas partial decomposed nature of cow dung showed less weight loss on the yield of vermicompost produce.

Table 3: Yield of vermicompost obtained

Treatment	Yield(kg)
T1 (Parthenium leaves)	0.76
T2 (Justicia leaves)	0.65
T3 (Banana stem)	0.73
T4 (Ashok leaves)	1.34
T5 (Cow dung)	1.78
Mean	1.05
LSD 0.05	0.21***
SEM(±)	0.051
CV %	10.69

Means followed by common letter (s) within column are non – significantly different based on DMRT at P = 0.05. NS: Non-significant. SEm: Standard Error of Mean. CV: Coefficient of Variation

3.1.4 Time required for maturation of different types of vermicompost

The time taken for the digestion of feeding materials for the preparation of vermicompost varied highly significant with feeding materials, which ranges from 76- 107 days (Table 4). Maturity was earlier in Cow dung feeding (76.33 days), followed by Parthenium leaves (79 days) and Justicia leaves (89 days). Time taken for banana stem was 93 days and ashok leaves 107 days.

The shortest time taken in cow dung is attributed to partially decomposed nature of cow dung as feeding materials. Similar result was reported by Tripathi et.al 2015 [42] that vermicompost maturity was significantly earlier in cow dung feed (101 days), followed by mixture, banana stem, grasses and cabbage. Similarly. The longest duration taken in ashok leaves may be of high fibers content and delayed decomposition of leaves as well as maturation of vermicomposting.

Table 4: Days required for vermicomposting

Treatment	Maturation Days of vermicompost
Parthenium(T1)	79
Justicia(T2)	89
Banana stem(T3)	93.67
Ashok(T4)	107.67
Cow dung(T5)	76.33
Mean	89.13
LSD 0.05	1.23***
SEM(±)	0.875
CV %	0.73

Means followed by common letter (s) within column are non – significantly different based on DMRT at P = 0.05. NS: Non-significant. SEm: Standard Error of Mean. CV: Coefficient of Variation

3.1.5 Nitrogen content of vermicompost

The result showed that the total nitrogen content of vermicompost produced from different feeding materials varied highly significantly with the types of feeding materials

(Table 1). Nutrient content was reported maximum on Ashok leaves (3.09%), followed by Justicia leaves (2.69%) and Parthenium leaves (2.08%). Nitrogen content on Banana stem was 2.03% and finally lowest on cow dung i.e. 1.93%.In this study, mortality rate of earthworm found higher in cow dung that might be the reason of low nitrogen content. Nitrogen content is higher in cow dung (2.1%) while banana stem contain 1.30% (Tripathi et. al 2015) [42]. Alie *et al.*, 2015 reported that Total kjehldahn nitrogen content (TKN g/kg) of cowdung was 1.20% According to Plaza *et al.* (2008) [28], N content of vermicompost increased due to mineralization of C-rich materials and N-fixing bacteria. Moreover, the earthworm itself has its role in generating N content derived from mucus, nitrogenous excretory substances, growing stimulating hormones, and enzymes (Tripathi G. and Bhardwaj P., 2004) [4]. Apart from that, decaying tissues of dead earthworms might contribute to the N content in the vermicompost produced, and similar analysis discussed by Suthar (2009) [39] approved this suggestion. Moreover, the mortality of earthworms also prevented the secretion of earthworm mucus (polysaccharide) to moisten its body surface for supplementing vermi beds with N-fixer bacteria (Singh D. and Suthar S., 2012) [36] and consequently the microbial propagation was retarded.

Rosset and Benjamin (1993) also reported that Cuban earthworm vermicompost contained 1.5 to 2.2% N and Gawande *et al.* (1998) recorded nitrogen content of vermicompost 1.12%. Vermicompost prepared from kitchen waste had more organic carbon, K and Fe and vermicompost prepared from cow dung and leaf litter had more P, K, Zn and leaf litter had more Cu. Hemalatha (2012) reported that vermicompost prepared from fruit and paper waste contained N 2.3% N, 0.51 P% and 0.54% K. Kale (1998) assessed the nutrient status of vermicompost prepared from different waste materials such as agricultural, urban solid and industrial wastes. It ranged between 0.5 to 1.5 per cent total nitrogen, 1.0 to 3.0 per cent available phosphorous. Reddy and Reddy (1998) [30] analysed nutrient status of organic matter and vermicompost. Vermicompost recorded 1.98% N, 1.23% P and 1.59% K.

Table 5: Nitrogen content of vermicompost produced from different feeding materials

Treatment	Nitrogen content
Parthenium(T1)	2.08
Justicia(T2)	2.69
Banana stem(T3)	2.03
Ashok(T4)	3.09
Cow dung(T5)	1.93
Mean	2.36
LSD 0.05	0.02***
SEM(±)	0.005
CV %	0.52

Means followed by common letter (s) within column are non – significantly different based on DMRT at P = 0.05. NS: Non-significant. SEm: Standard Error of Mean. CV: Coefficient of Variation

4. Conclusion

From the study it can be concluded that among the various feeding materials Justicia leaves was found to be the suitable feeding material as it showed higher multiplication ratio of earthworm. Similarly no. of cocoon production was also found highest on Justicia as compared to others substrates. In case of yield, vermicompost produced was low on Justicia leaves whereas maximum on cow dung followed by Ashok leaves. Ashok leaves takes maximum days for decomposition as well as maturation whereas Cow dung takes minimum days for maturation of vermicompost. Nitrogen content was low on cow dung as compared to others whereas maximum on Ashok leaves followed by Justicia leaves.

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