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Utilization of Agricultural Wastes as Substrates for Vermicomposting

[1]Saratendra Bajal*, [1]Sandesh Subedi, [1]Suraksha Baral
[1]*Bachelor Graduate, Agriculture and Forestry University, Nepal*
Corresponding author: Saratendra Bajal

Abstract: *Vermicomposting is the process of conversion of bio-degradable wastes into high quality manure through the use of earthworms. It is a cost effective method of producing organic fertilizer and a reliable means of bio-waste management. A research was carried out at Agriculture and Forestry University, Nepal, to identify the manuring potential of different agricultural wastes through vermicomposting. Eisenia foetida, an epigeic species of earthworm was used for the conversion of these wastes into manure. The research consisted of eight treatments with three replications for each treatment in completely randomized design. Plastic bins of diameter 43 cm and height 16 cm were used for composting purpose where 200 earthworms of similar size were introduced in all bins except in control treatment. The substrates used in vermicomposting were Lantana camara, Ageratum conyzoides, banana pseudo stem, garden waste, vegetable waste and cow dung. Cow dung alone and mixture of cow dung with respective substrates were subjected to vermicomposting. Vermicompost samples collected after seventy five days upon the completion of process were analyzed for NPK content and compared with each other. All vermicompost samples were high in nutrient content than the control; however, nutrient content varied significantly among the substrates. Similarly, all other samples were superior to sole cow dung vermicompost. Lantana camara, mycostraw and Ageratum conyzoides contained highest percentage of Nitrogen, Phosphorous and Potassium respectively. In an Overall comparison, Lantana was found most effective with 2.53% N, 1.38% P and 2.28% P.*

Keywords:*Vermicomposting, earthworms, substrate, agricultural waste, waste management, organic farming*

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I. Introduction

In agriculture, after making use of economic parts, large amount of biological yield is neglected in the form of waste. Agricultural waste results in the form of crop residues, weeds, undesired plant parts, leaf litter, bedding materials of animals, crop and livestock by-products. Such wastes are produced during the intercultural operations, harvesting or any other managerial practices. An estimated 3.8 billion tons of crop residues is generated every year by the world's agricultural sector (Lal, 2005). India alone generates about 620 million tons agricultural residue out of which more than half remains unutilized (Singh & Nain, 2014). Such wastes are generally burned in the field by farmers without considering its negative impacts that disturbs the soil physical, chemical and biological properties altering the microbial activities as well as causes an imbalance in agro ecosystem due to air pollution (Singh & Prabha, 2017). In Nepal, organic waste from plant based product is estimated to be 2.5 million ton/year which can be potentially used as the source of organic fertilizer production (Pokhrel & Viraraghavan, 2005).

Similarly, the urban areas produce green waste from garden or park. Waste from hedge trimming, flower cutting, domestic and commercial food waste, vegetable and fruit market waste which is accumulated haphazardly worsen hygiene and sanitary condition of cities mainly in the developing countries (Pattnaik & Reddy, 2010). Furthermore, large amount of bio-degradable waste is generated in the form of kitchen and household waste that poses a great challenge in waste management mainly in the urban areas. Over 70% of the city waste by volume in Nepal is decomposable and recyclable in the ground (Dhital, Sharma, & Adhikari, 2016). Vermicomposting is one of the eco-friendly way of converting such bio-degradable wastes into high quality manure (Patrabansh, 2002).

Vermicomposting is the process of conversion of organic wastes by certain species of earthworms to valuable humus like material which is used as natural soil conditioner (Dominguez & Edwards, 2004). Epigeic species of earthworm are commonly used earthworms for vermicomposting. Due to their natural ability to feed organic wastes, high reproduction rate and short life cycle epigeic species are considered suitable for vermicomposting. Among different species of epigeic type,*Eisenia foetida* is extensively used for vermicomposting (Garg, Satya, & Gupta, 2006; Aalok, Soni, & Tripathi, 2009).

Vermicomposting is an environment friendly and cost effective techniques for solid waste management and sustainable agriculture (Manaig, 2016). Vermicomposting is beneficial to us in two ways as it helps in degradation of solid waste and the worm cast can be used as organic fertilizer(Mehta & Karnwal, 2013). Vermicompost is finely divided manure with high porosity, aeration, organic matter content and high water holding capacity and rich in microbial activities due to the interaction between earthworm and micro-organisms (Dominguez & Edwards, 2004). It is rich in NPK, micronutrients, beneficial microbes and contain plant hormones and enzymes as well in contrast to the conventional compost. It is proving to be a wonderful growth promoter as well as plant protector from diseases and pests (Sinha & Herat, 2002). When the whole world is hopefully looking for economically viable, socially acceptable and environmentally safe and sustainable alternative to chemical method of farming due to the adverse effect of chemicals on soil health as well as on human health, vermicomposting can offer the best path towards desired organic farming (Adhikary, 2012).

Different biological and agricultural wastes can be used as substrates for vermicomposting. The judicious use of such organic wastes might enhance the quality of compost formed. Quality of vermicompost mainly depends upon types of raw material used and species of earthworm used (Jafarpour, Pessarakli, & Kazemi, 2017). Selection of substrates and their combination is an important step in vermicomposting as it influence the activity of worms and alters the quality of manure formed. The efficiency of vermicompost is measured by number of worms, time taken for conversion and biomass produced (Manaig, 2016). Besides, this the lowering of C: N ratio by conversion of organic carbon into carbon dioxide which is lost to the atmosphere and excretion of nitrogenous wastes by earthworms enhance the nutritional efficiency of manure produced (Mahanta & Jha, 2009). This research aimed to utilize various garden and field crop wastes as substrates for vermicomposting to identify their manuring potential.

II. Materials And Methods

Experimental site

The research was carried out in 2018 AD under the shed house of horticulture farm at Agriculture and Forestry University, Rampur, Chitwan, Nepal.

Collection of Substrate and Earthworm

The substrates required for vermicomposting were collected within the premises of Agriculture and Forestry University and earthworms were brought from a nearby vermicompost farm.

Substrates used

Cow dung

Cattle manure is an excellent food for earthworms in vermicomposting. It acts as a cake for earthworm during composting purpose (Munroe, 2007). In this research cow dung was used as basic food material in each compost bin. Fifteen days old partially decomposed cow dung was used in this research as fresh cow dung could be harmful to earthworms due to heating process.

Lantana camara

Lantana camara is a common and aggressive shrubby weed found in different parts of Nepal. Due to its highly allopathic nature it can cause toxicity in grazing animals. However, vermicomposting can eliminate toxicity of this weed and can turn it into excellent organic fertilizer (Hussain, Abbasi, & Abbasi, 2015).

Ageratum conyzoides

Ageratum conyzoides is an annual, herbaceous weed of many annual and perennial crops and also the host of many crop diseases. Use of *Ageratum* and other obnoxious weed is economical for low cost vermicomposting technology (Chaudary & Suri, 2018).

Banana pseudo stem

Banana pseudo stem is trunk of banana which is formed by tightly packed leaf sheaths. Once the fruits are harvested this pseudo stem is discarded in the form of biomass waste (Subagyo & Chafidz, 2018). For every ton of banana fruit harvested about four tons of biomass (pseudo stem, leaf, peel, rhizome etc.) is wasted. This banana waste can be utilized to make quality compost using epigeic earthworms (Kavitha, Ravikumar, & Manivannan, 2010).

Garden waste

Garden waste comprised of lawn grass and hedge trimmings such as *Justicea*and *Duranta.*

Vegetable waste

Crop residues of cauliflower, cabbage and broccoli after harvesting were used as substrate for vermicomposting. Such harvested residues were collected from the field where pesticides and insecticides were not used during the cropping period.

Mycostraw

Mycostraw is the residue of mushroom farming. Paddy straw is used as substrate in cultivation of oyster mushroom. After the mushroom is harvested this residue is rejected in the form of waste. This rejected waste

containing mushroom pieces is a good organic carbon rich component to use as a substrate for vermicomposting. This makes mushroom cultivation and vermicomposting complementary to each other (Tah, 2013).

Bedding material

Rice straw

Bedding is any material which provides hospitable living material and stable environment for earthworms. In general, bedding material must have high absorbency, good bulking potential and high carbon to nitrogen ratio (Munroe, 2007). Paddy straw is commonly available agricultural waste as it is most widely cultivated cereal crop in Nepal (MOALD, 2017). It is cheap source of organic fertilizer, contains high C: N ratio; therefore making it a good bedding material for vermicomposting (Manaig, 2016).

Experimental setup

Preparation of compost bin

The experimental setup consisted of eight different treatments with three replications for each treatment, arranged in completely randomized design. Pre-composting was done for about ten days and the substrates were introduced to plastic bins of diameter 43 cm and height 16 cm. Chopped paddy straw was used as bedding material in each treatment. The substrates used for vermicomposting were Cow dung, leaves of *Lantana* camara, *Ageratum conyzoides*, banana pseudo stem, garden waste, vegetable waste and mycostraw. The control treatment consisted of cow dung and was devoid of earthworms. In another treatment earthworms were fed solely with cow dung while other treatments consisted of one kg cow dung as base food material and two kg of required substrate according to the treatment. The detail of treatments and composition of substrates is presented in table 1.

Eisenia foetida species of earthworm were used for vermicomposting with 200 worms of almost same size in each bins except in control. Gunny bags were used to cover the bins to create dark condition favored by the worms. The Vermi liquor seeping out of the holes drilled at the bottom of bin was collected in the vessel underneath the compost bin. Vermi wash thus collected was poured into the same bin until the compost was fully prepared.

Table 1: Composition of treatments

Treatment	Substrate used	Amount of Cow dung used(kg)	Amount of substrate used (kg)	Number of earthworms used
T_1	Leaves of *Lantana camara*	1	2	200
T_2	Whole plant of *Ageratum conyzoides*	1	2	200
T_3	Banana pseudo stem	1	2	200
T_4	Garden waste	1	2	200
T_5	Vegetable waste	1	2	200
T_6	Mycostraw	1	2	200
T_7	Cowdung	3	0	200
T_8	control	3	0	0

Maintenance of moisture and temperature

Adequate moisture was maintained by sprinkling enough water at a regular basis. The temperature range of experimental site was 30-35 degree Celsius during this research.

Collection of sample

The process of vermicomposting was carried out for a period of 75 days. At the end of experiment total earthworm count in each treatment was calculated and vermicompost sample was collected for nutrient analysis.

Nutrient Analysis

The samples were analyzed for Nitrogen (N), Phosphorous (P) and Potassium (K) at Regional Soil Testing Lab Pokhara, Nepal.

Statistical Analysis

The data were entered in MS-excel and analysis was done using Rstudio.

III. Resultand Discussions

A fine, granular, odorless, black peat like structured compost was obtained after seventy five days in all treatments which marked the potentiality and suitability of all the substrates for vermicomposting purpose. Thus, collected sample were analyzed for nutrient content. The vermicompost from different substrates were found rich in N, P, and K contents. However, Nutritional composition of vermicompost varied with substrate used.

Comparison of NPK content of vermicompost sample is presented in table 2.

Table 2: Analysis of NPK content of vermicompost samples of different substrates

Treatment	**Nitrogen content**
Substrate medium	
Lantana camara	2.53[a]
Banana Pseudo stem	2.49[a]
Ageratum Conyzoides	1.91[b]
Garden Waste	1.87[b]
Vegetable Waste	1.85[b]
Mycostraw	1.81[b]
Cowdung	1.26[c]
Control	0.48[d]
Sem(±)	0.13
LSD(0.05)	0.324
CV	11
F-test	***

*** indicates significance at 0.01%

Treatment	**Phosphorous content**
Substrate medium	
Mycostraw	1.46[a]
Vegetable Waste	1.43[a]
Lantana Camara	1.38[a]
Ageratum Conyzoides	1.33[a]
Garden Waste	1.32[a]
Banana Pseudo stem	1.31[ab]
Cowdung	1.08[b]
Control	0.30[c]
Sem(±)	0.08
LSD(0.05)	0.235
CV	11.1
F-test	***

*** indicates significance at 0.01%

Treatment	**Potassium content**
Substrate medium	
Ageratum Conyzoides	3.29[a]
Banana Pseudo stem	2.46[b]
Lantana Camara	2.28[bc]
Mycostraw	2.01[bc]
Garden Waste	1.87[bc]
Vegetable Waste	1.64[cd]
Cowdung	1.04[de]
Control	0.29[e]
Sem(±)	0.19
LSD(0.05)	0.793
CV	24.3
F-test	***

*** indicates significance at 0.01%

The result showed that nutrient content of all the samples were significantly higher than that of control. It might be due the reason that control treatment lacked earthworms; therefore, it was similar to conventional compost while in other substrates earthworms were used for vermicomposting. It was found that no matter whatever was the substrate used for composting, NPK content of vermicompost was higher than that of Farmyard manure (Pattnaik & Reddy, 2010).

Nitrogen content was found significantly more in those vermicompost samples which contained additional substrate than cow dung alone. Cow dung alone (1.26% N) had also significantly higher nitrogen content than control (0.48% N); however, mixture of any plant material along with cow dung was found better in terms of percentage of nitrogen. Highest amount of nitrogen was recorded in *Lantana camara* (2.53%). However, both *Lantana camara* (2.53% N) and banana pseudo stem (2.49 % N) were statistically equivalent to each other but superior to other samples. Similarly *Ageratum conyzoides*, garden waste, vegetable waste and mycostraw were equivalent to each other in terms of nitrogen content.

Highest amount of phosphorous was recorded in mycostraw (1.46%) and lowest was recorded in control treatment (0.30%). However, no significant difference was found between mycostraw, vegetable waste, Lantana camara, Ageratum conyzoides, and garden waste. Cow dung alone as a substrate was also significantly superior to control; however, all the other treatments were found superior even to cow dung.

In case of potassium, Ageratum *conyzoides* (3.29%)contained significantly higher amount of potassium than any other samples. There was not much difference between other substrates used for vermicomposting; however, all the samples were found superior to control treatment.

Vermicomposting is the result of both physical and biochemical action of earthworms. Physical action includes mixing up, loosening, aeration, maintenance of aerobic condition and the grinding of waste by earthworms whereas biochemical action includes breakdown of substrates by useful micro-organisms in the gut of earthworm. Thus, the earthworms act to modify physical and chemical status of waste, reduces C: N ratio making it an odorless, finely divided peat like material with high porosity and water holding capacity along with enhanced nutrient contents. (Dominguez & Edwards, 2004; Lazcanoa & Domínguez, 2011).

Panta & Yami, 2008, found that decomposition process was enhanced and nutrient content was increased due to the presence of earthworms and aerobic heterotrophic population of microbes. The increased content of plant useable form of nitrogen, phosphorous and potassium might be due to rapid mineralization of wastes due to the action of earthworms (Aalok, Soni, & Tripathi, 2009; Manaig, 2016). It was cited as well as explained that quality of vermicompost always depend on the type of substrate used for composting (Garg, Satya, & Gupta, 2006; Manaig, 2016; Panta & Yami, 2008) However, the mixture of plant waste and cow dung was suitable for preparation of high quality compost. It was superior in terms of NPK content than the cow dung or the substrate alone. (Mistry, Mukhopadhyay, & Baur, 2015).

IV. Conclusions

Vermicomposting is a cost effective technology to produce high quality manure from bio-degradable solid wastes with the help of earthworms. Therefore it has a great role in waste management and in promoting organic agriculture. Discarded crop residues and menacing crop weeds can be utilized as substrates for vermicomposting to produce a nutrient rich soil conditioner. Vermi- composting of leaf litter, crop residues and weeds can be an effective solution to waste and weed management in the farm, forest and urban areas. Furthermore it can be a great source for the much needed organic fertilizer (Aalok, Soni, & Tripathi, 2009). The type of substrate used can influence the quality and nutrient content of vermicompost. This study found that any suitable substrate subjected to vermicomposting makes better compost than the conventional cow dung compost. Furthermore, mixture of cow dung with other plant residues makes a better substrate which yield vermicompost with enhanced nutrient content. Among different substrates used for vermicomposting *Lantana camara* was found most effective which contained highest nitrogen content (2.53%) followed by banana pseudo stem (2.49%). Though the phosphorous content (1.38%) was not highest in *Lantana* but it was significantly equal to mycostraw (1.46%) and vegetable waste (1.43%). In case of potassium content, *Ageratum* has highest amount (3.29%) followed by Banana pseudo stem (2.46%) and *Lantana* (2.28%). Thus, *Lantana, Ageratum and* Banana pseudo stem seemed to be richer in NPK content than others.However, it can be concluded that all the substrates used in this research have high manuring potential and can be effectively utilized through vermicomposting.

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