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RESEARCH ARTICLE

VERMICOMPOSTING FOR ORGANIC WASTE MANAGEMENT

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ABSTRACT

Changing life style and increase in population has increased the waste load in the environment, and as a result the existing waste dumping sites are full beyond capacity, which leads to pollution of water resources, spreading communicable diseases, foul smell etc. Vermicomposting is better option to tackle all these problems. It helps in degradation of solid waste, and also it is cost effective technique. Vermicomposting is a bio-oxidative process, which involves earthworms. For this mainly *Eisenia fetida* species of earthworms are used.

The present study was carried out for recycling of organic waste like Cow dung etc. Moisture content and temperature was maintained. The parameter such as pH, Carbon, Nitrogen and Protein are measured during the specific interval of time in which result show that the nutrient content is increases at the end of the day. The process of Vermicomposting promotes plant growth, improves soil quality and helpful in managing different kinds of agricultural, industrial and domestic wastes. Therefore, Vermicomposting is highly nutritive 'Organic Fertilizer'. It retains soil nutrients for long time.

INTRODUCTION

Soil is one of the most important natural resource on earth. Most life on earth depends on soil as a direct or indirect source of food, but deterioration of the environment through depletion of resources is a major threat confronting the world. The widespread use of chemical fertilizers has contributed to environmental degradation especially on soil fertility by reducing the natural nutrients on the soil surface. Though intensive use of chemical fertilizers in agriculture increases the crop production but at the same time it causes negative impact on land, air, water and on environmental health. Concerns regarding soil degradation and agricultural sustainability have kindled interest in assessment of soil quality (Haynes, 1997) [1].

Soil quality refers to the capacity of soil to accept, store and recycle nutrients and water so that economic yields are obtained without deterioration of environmental quality. Soil fauna communities, including soil invertebrates, are known to improve soil structure by decreasing bulk density, increasing soil pore space, soil horizon mixing, increased aeration and drainage, increased water holding capacity, litter decomposition and improving soil aggregate structure (Witt, 1997) [2].

Earthworms, an important soil fauna group in most ecosystems contributes to distribution of litter surface, enhance soil nutrient cycling through the rapid incorporation of detritus in to mineral soils. Earthworms also accelerate the mineralization as well as the turnover of soil organic matter. Earthworms are known as "Farmer's Friend", "Nature's Best Friend". Past experience teaches us to replace the use of chemical fertilizers with the organic manure. There are many different methods to produce compost manure using earthworms. One of the most important earthworm families is Lumbricidae, and one of its members, *Eisenia fetida*, can be used to stabilize organic waste by the process called "Vermicomposing" or composting with worms (Pirsaheb *et.al*., 2013) [3].

Nutrients content of the vermin-compost is much higher. Earthworms are responsible for breaking down of complex substances in the organic waste in to simple water-soluble substances (Datar, 2006-07) [4]. Earthworms tolerate widest range of environmental conditions and fluctuations occurring in their surroundings. They easily grow on high-density organic solids. There are about 3,627 species of terrestrial earthworms

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in the world (Samaranayake, 2010) [5]. Different species of earthworms play different roles in soil and the utilization of organic wastes through them is called Vermicomposting. Vermin-compost provides major nutrients to the soil for plant growth and also consists of important vitamins and growth hormones. *Eisenia fetida* is most commonly used for the management of organic wastes. It lives in the upper layer of soil surface and is non-burrowing species of earthworms. The non-burrowing types are red or purple and 10 to 15 cms long, but their life span is only 28 months, *Eisenia fetida* showed increase in Carbon, total Nitrogen content as compared to other species. The burrowing types are pale and live deep in the soil. The non-burrowing earthworms eat 10% soil and 90% organic waste materials; these convert the organic waste into vermi-compost faster than the burrowing earthworms (Kamineni V K, 2014) [6].

Earthworms live and breed at temperatures between 55 and 85 degrees Fahrenheit (Sherman, 2003) [7]. For commercial production, earthworm bed should be kept at 6.8 to 7.2 pH range, but normally they grow in soil having pH range of 4.2 to 8.0. Vermicomposting is a simple bio-technological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better product (Adhikary, 2012) [8].

Vermin-composting and composting, both are different from each other. Vermicomposting process is faster than composting because it utilizes earthworms which transform garbage in to 'gold'. In India, anaerobic composting practices have been done mainly for recycling of organic wastes by collecting different kinds of organic residues from various farm activities along with cow dung and is normally piled up on the ground surface and watered to maintain 40-60% moisture. It is advisable to practice vermi-composting in sheltered, protected conditions to avoid the problem of unpredictable rains and bright sunshine. Earthworms that are identified for culturing are released on the surface layer (Kale, 1994) [9].

Several studies have been reported from around the world, in terms of consumption of different types of residues such as Sewage Sludge, Industrial wastes, Agricultural wastes by earthworms an converting it in to vermicompost. An experimental study was conducted by Hemalatha (2012) [10] to obtain the vermicompost using partially decomposed fruit waste with paper and tannery industry sludge's. Londhe and Bhosle (2015) [11] conducted a study on recycling of solid wastes in to organic fertilizers using low cost treatments and found that E fetida earthworm mainly applicable for vegetable and fruit waste. P Laxshmi *et.al* (2013) [12] prepare vermin-compost from temple waste flower and significant differences were observed in the plants grown in the vermin-composting as compared to the plants grown in soil without vermin-composting.

Growth of Eisenia fetida in various animal wastes

The selection of suitable earthworm species is an important step for the process of vermin-composting. There are thousands of species of earthworms, but only a few of them are suitable for vermin-composting of organic waste. A study conducted by Loh *et.al.* (2005) [13] and find that cattle manure provided a better environment for the earthworm to grow and it produced a higher quantity of vermicast than did goat manure. Worms in cattle manure produced a higher number of cocoons and young worms. In another study by Gunadi and Edwards (2003) [14] and observed that growth of E. fetida in growing-finish pig solids and sow pig solids was faster than in either separated cattle solids or pre-composted cattle solids.

Different methods of vermicomposting

At International Crops Research Institute for the Semi-arid Tropics, Patancheru, Andhra Pradesh, a number of methods i.e. pit below the ground, heaping above the ground, tanks above the ground, cement rings and commercial model have been discussed by Nagavellemma *et.al.* (2004) [15] and found that utilization of vermicompost in several benefits to farmers, industries, environment and overall national economy like; better quantity and quality in crops, cost-effective pollution abatement in technology and less wasteland formation.

MATERIALS AND METHODS

Study site, Treatments and Soil Sampling

The present study was carried out in Vermicompost experimental plots set up by Manthan at Shardanand Gurukul, Kurukshetra (29^{0}56' N, 76^{0}51' E). A field visit was made to Budha village near Ladwa to study the on farm trial of Vermicompost using agricultural wastes and cow dung. Kurukshetra district is situated 160 kms north of Delhi on the National highway NH1. Other towns of the district are Pehowa, Ladwa, Ismailabad and Shahbad. The district is a plain, which slopes generally from North East to South West. A good network of canals is providing irrigational facilities. Underground water level is not relatively high. Kurukshetra along with Karnal and Kaithal districts is known as the 'Rice Bowl of India' and famous for Basmati rice. Soil is generally alluvial, loan and clay does not constitute average texture of the soil.

Method Adopted for Organic Waste Management in Gurukul

Gurukul is one of the oldest educational institutes in Haryana and was established in 1912 in Kurukshetra, and is spread over 1000 acres of land. It is known for its good quality education with traditional Indian culture and morals.

It is known for its modern technology. Besides, an educational institution, it is accomplished with Yoga center, a Naturopathy hospital, a medicinal plant garden, solar heaters, Vermicompost, a cow-shed, a horse yard. Energy needs of Gurukul at a large scale are being fulfilled by partially (35%) from the electricity generated from Biogas plants. There is a big cowshed spread over an area of 1 acre and the data on number of cows and other animals in the cowshed are about 160 {Cows (72+), Calves (63+), Pregnant Calves (24+), House (1)}. The animal waste generated from the animals is about 1800 to 2000kg per day and the total milk production per day is about 500kg.

Specifications of Biogas plant of Gurukul

Biogas plant facility is spread in the area of 1.5acres in Gurukul. There are two working Biogas plants of Dome shaped floating gas holder type. It consists of a Dome like structure, made up of iron, which floats as a pressure of biogas involved increases. This type of Biogas plant is more frequently used where cow dung is used to obtain Biogas. Depth of both plants is 20ft and 20ft respectively.

Soil Sampling

Soil sampling was performed after 30 and 60 days of Vermicompost. After removing the ground floor litter and plant residues, the underlying soil was sampled using a soil corer (12cm diameter) at depth interval of 0-10 and 10-20cm. Three soil samples for each depth were obtained. Samples were transported to the Laboratory in polythene bags and stored at 4 degree celcius until analysis. Samples were air dried, sieved using sieve (<2mm) discarding only the recognizable plant debris, pebbles and stored at room temperature prior chemical, bio-chemical and physical analysis.

Soil chemical and Biological analysis

Temperature and pH estimation

Temperature and pH was recorded every 12^{th} day with thermometer and pH of the sample was determined by the standard electrometric method for every 12^{th} day.

Mycorrhizal Root Colonization of Plant species

Roots of herbaceous plants were collected randomly, washed and cut in to 1-2cm segments, cleared with 10% KOH for 24 hours. After the KOH was drained out and roots were washed with 1% HCl for 1 minute and then washed with water. Root segments were stained with Trypan blue. The stained roots were mounted in Lactic acid glycerol (1:1) solution and examined under the binocular light microscope. Percent root colonization was calculated using the formula given as below:
% root colonization = no. of segments colonized with VAM / total no. of segments observed x100

Isolation of Arbuscular Mycorrhizal spores

To isolate the AM fungal spores, soil samples were collected by digging out the soil close to the plant roots up to a depth of 10-15cm. Population of Arbuscular Mycorrhizal (AM) spores in the Rhizosphere soil was determined by wet sieving and decanting method. Spores were mounted in Lacto-phenol and were identified with the help of standard key.

Total Organic Carbon (TOC) content estimation

TOC was estimated by Walky and black method (Trivedi and Goel, 1986)[16];

1. Oven dried sample was passed through 0.5 mm sieve then 10 grams of the sample was added to 500ml flask.
2. 10 ml of 1N $K_2Cr_2O_7$ AND 20 ML of Concentrated H_2SO_4 was mixed in it. Flask was then kept for 30 minutes for incubation then content was diluted to 200 ml with distilled water.
3. 10 ml of phosphoric acid and 1ml of DPA indicator was added to the sample and was then titrated against 0.5N ferrous ammonium sulphate. End point was brilliant green.

% Carbon = 3.951/G X (1-T/S)
Where;
G = wt. of the sample
T = Titration reading in ml.
S = ml of Ferrous ammonium sulphate

The organic carbon content of the soil sample is oxidized by nascent oxygen produced during reaction of Sulphuric acid with aqueous solution of Potassium Chromate. The residual potassium chromate is titrated with Ferrous Ammonium Sulphate (Mohr's salt solution).

Percent carbon = vol. of potassium chromate X normality of potassium chromate X (B-E)X 0.003/Vol. of FASB X wt. Of soil sample taken x 100

Estimation of protein content

The Protein content was estimated in seeds of Vermicompost rice by Kjeldal method (FAO, Food and nutrition paper 77, 2002) [17], grinded rice powder is digested with concentrated Sulphuric acid and catalyst till it becomes colorless. Then it is allowed to react with NaOH solution which will liberate ammonia. This ammonia is absorbed by the boric acid and boric acid is titrated with N/70 HCl using mixing indicator. Total nitrogen content in seeds is then calculated using following formula;

Total nitrogen in seeds (mg/l) = vol of HCl used x normality of HCl x 14/wt. of rice sample x100

And

Total protein content in rice is calculated using formula = total nitrogen / 6.25

RESULTS AND DISCUSSION

Process of biogas production

Biogas refers to a gas produced by the biological breakdown of organic matter in the absence of Oxygen, comprised primarily of Methane and Carbon dioxide. It is a product of the anaerobic digestion or fermentation of bio-degradable material such as manure or sewage, municipal waste and energy crops.

Microbial activity and major factors affecting the biogas production

Microbial conversion of organic matter to methane has become attractive as a method of waste treatment and resource recovery. Most important bacteria involved in biogas productive process are anaerobes and slow growing. Slurry is the mixture of cattle dung and water. About 15-20 quintals of slurry is daily fed in to the digesters of the biogas plants in Gurukul. In Gurukul two types of raw materials are used for Vermicomposting i.e. cow dung and semi solid slurry, ejected from biogas plant. Mainly Redworms or *Eisenia fetida* species of earthworms are used for Vermicomposting. The heap method of producing Vermicompost was used at Gurukul and the bed method was used at Budha village.

Plant growth promoting activity

Growth promoting activity of Vermicompost was recorded and a good response of the Vermicompost on the production of seedlings was observed.

Improved crop growth and yield

The crops, wheat and some horticulture plants were raised using Vermicompost in Gurukul and there was a beneficial effect of Vermicompost on the growth of horticulture plants. The wheat responded well to the amendment of Vermicompost. There was greater protein content in seeds of rice amended with Vermicompost. The use of organic manures is highly effective to achieve and sustain reasonable yield levels of wheat. Organic manures help to maintain biological processes and soil physical properties. The AM fungal root colonization was studied in wheat growing with Vermicompost. Most of the wheat root seeding stages were colonized by AM Fungal Hyphae. The colonization of roots viewed from 92-98% in five observed samples. In the studied root samples, different types of root colonization and formation of Arbuscules and Vesicles was observed.

Improved soil physical, chemical and biological properties

Vermicompost improved air-water relationship in the soil which favourly affects pit growth. The application of organic matter including vermicompost favorably affects soil pH and AM fungal colonization of roots of wheat. There was increase in Nitrogen content, total organic carbon and pH values in soil amended with vermicompost. The contents of humus and microbial biomass carbon in soils fertilized with vermicompost were increased compared with those receiving inorganic fertilizers only. There was increase in soil microbial activity with the addition of organic fertilizers.

CONCLUSION

Waste is generally organic and inorganic in nature. Organic waste mainly consists of food, vegetable, fruit, paper and agricultural waste etc. These types of Organic wastes are bio-degradable in nature and Vermicomposting is the best option which helps in degradation of solid wastes. Incorporation of Vermicomposting to soil improved soil physical and biological properties. The Vermicomposting application had a positive effect on the soil physical, chemical and biological properties, increasing plant cover and decreasing the soil losses.

Following are some conclusions of the present study

1. In the present work, *Eisenia fetida*, most common species of earthworms are used and the study shows that the good quality of Organic compost was obtained.
2. The important nutrients present in the soil increase in all treatments.
3. The study area is economical in construction and maintenance.
4. The process of obtaining bio-compost is totally natural.
5. From the present study, it can be concluded that earthworms are important creatures that are capable of transforming waste into gold.
6. In Gurukul, the animal waste generated from the animals is about 1800 to 2000 kg per day.
7. In the present study, the key parameters like Carbon, Nitrogen, Protein content and pH showed increase at the end of the day.
8. *Eisenia fetida* is helpful in improving soil quality.

Advantages of vermicomposting

1. It is a natural bio-oxidative process.
2. In this process, decomposition of biodegradable waste is easy.
3. No external energy is required.

Future scope of the study

1. Different other parameters can be studied like Phosphorus content, Electrical conductivity etc.
2. Vermicomposting as a fertilizer for other different types of crops can be studied.

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