

## Review Article

# Earth Worms and Vermicomposting: A Review on the Story of Black Gold

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**Abstract** | Presenting the world state of the art review, which summarizes the core ideas from experiments performed by expert researchers on vermicomposting. Vermicompost is a finely decomposed peat like material having good aeration, high drainage, good water holding capacity, microbial activity, superior in nutrient status and buffering capacity therefore having the amiable required physiochemical charms for fertility of soil and growth of plant. The worms increase the biological decomposition of organic substrates by maintaining the aerobic conditions of the organic substrates. Experiments on earthworms and the vermicast production by different species are also included in review. The paper also reveals fitness or compatibility of different species of earthworms to 'bioprocess' variation in different forms of organic waste. The review also presents the basic idea of all those research studies about effect of vermicomposting on different parameters of plant growth. Such an explanatory review is remarkably few and far among studies about the impact on plants of vermicasts prepared from aquatic weeds and agriculture wastes.

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## 1. Introduction

Vermicomposting is a term coined to explain the whole process of utilization of biodegradable material by earthworms and producing vermicasts. The process enhances the bioavailability of basic nutrients by consuming raw nutrients and reproducing useful byproducts. Vermicast is also reported for having descend of growth sufficient hormones *i.e.*

ethylene, auxin, gibberellin and enzymes *i.e.* cellulose, nitrogenase, phosphatase etc. Those nutrients are produced during the passage of degradable mass through the gut of earthworm. It is also a strong belief that all such hormones and enzymes are plant growth stimulants while inhibit the pathogen invasion causing different diseases. The environmental friendly and pure organic highly nutritious fertilizer vermicompost fertilizer is used for crop production

and soil management (Celik et al., 2020). Overall, the vermicast is recommended for its organic fertilizing ability along with soil conditioning. The most recent experiments reported by concerned researchers (Aslam et al., 2020; Aslam and Ahmad, 2020; Belliturk et al., 2020) revealed the potential of vermicomposting for beneficial effects on plants. In this review paper, the authors are presenting a brief but comprehensive review of vermicomposting and special features of the process involving all frontline players responsible for nutrient enrichment by earthworms.

### 1.1 Earthworm

Earthworms (Table 1) taxonomically classify into phylum annelida and are long, cylindrical, narrow, segmented and symmetrically bilateral soil inhabiting invertebrates having a glittering brownish body encased with smooth cuticular layer. The weight of earthworms range to 1400-1500 mg after ½ month and are reproductively hermaphrodite. The body of earthworm comprises protein (65%), carbohydrates and fat (14%) and 3% ash. The life cycle of earthworm differs within 3-7 years relying on the ecological conditions. The earthworm gut is linear tube initiate from mouth part accompanied by pharyngeal, esophagus, slender walled crop, gizzard, digestive glands and ultimately terminate with anal cavity. Mucus found in gut of earthworm including amino acids, minerals, organic matter, polysaccharide and protein as well symbiotic microbes namely (micro-fungi, protozoa and bacteria). Enhancement in total organic C:N and moisture content of earthworm gut generate suitable condition for germination of bacterial endospore and activation of dormant microorganisms. Amylase, protease, cellulase, chitinase, protease, lipase and urease like digestive enzymes have been reported from the food canal of earthworm. It was found that mannose and cellulose were being carried out through the gut of microbes (Munnoli et al., 2010). Earthworms break down the raw material and thus increase the surface area of microbial degrading substrates that starts the active vermicomposting stage. As the organic matter carry through the intestine, it is mixed with microbes associated with intestine and digestive enzymes and finally in partially digested form as “casts” removes from the intestine after which the process of degradation starts by microbes, which participate to the maturation period (Aslam et al., 2020; Ahmad et al., 2021).

Earthworms and microflora interaction is very

complex and therefore earthworms digested the various groups of microorganisms as dietary source. These microbes contain protozoa, few yeasts and certain species of fungus as *Fusarium oxysporum*, *Alternaria solani*, *Drawida calebi*. *Bacillus cereus* var *mycoides* were digested by the species of earthworm *Lumbricus terrestris* and *Eisenia foetida* whereas *Serratia marcescens* and *Escherichia coli* are not included in passage through intestine of earthworm (Aslam et al., 2020; Ahmad et al., 2021).

### 1.2 Characteristics of *Eisenia foetida*

*Eisenia foetida* (Savigny, 1926) belongs to the phylum Annelida and family lumbricidae (Pavliček and Csuzdi, 2012). These worms are red, purple, or brown in colour, with a yellowish belly. Its segment number ranges from 80 to 110, with lengths ranging from 23 to 130 mm. Among segments 24, 25, 26, or 32, the genital belt extends to 7-9 pieces during puberty. The weight of the adult worm is about 1.5 g and they can reproduce about 50 to 55 days when they come out of the cocoon. Adult worms will produce a cocoon every three days on average, with one third of newborns coming out of the cocoon after 23 days. Although all infants do not survive (Belliturk et al., 2020).

*Esienia foetida* (Figure 1) is a type of surface-born waste-born and fertilizer-maker, and its inhabitants are mass manure, horticultural land with large quantities of organic material, forest and areas with a lot of wood and leaves waste, and it can serve as a suitable degrading in soil. It can live in a wide range of environment types and is active in all seasons. The intake and reproduction rate of food in these worms is high and they are rich in organic matter and have life, nutrition and reproduction potential in environments so that these worms use the daily equivalent of half their weight of organic waste (Tohidinejad et al., 2011).



**Figure 1: *Eisenia foetida* in (A) Rice straw, (B) Wheat straw.**

### 1.3 Vermicomposting

Vermicomposting (Figure 2) is viable and eco-friendly technology which is mainly integrated to convert waste organic residue into useful organic rich humus under aerobic condition. Vermicomposting noticeably involve in degradation and stabilization of solid organic waste frictions into fine organic rich manure derived from vermicompost processing can be efficiently reserved, handled and integrated to agricultural lands without any negative impacts (Aslam *et al.*, 2020). Vermicomposting is an integrated interaction of earthworms and mesophilic microorganisms in ecofriendly environment and stabilized conditions in order to attain non-thermophilic degradation and stabilization of solid organic waste frictions. (Aslam and Ahmad, 2020). Production of vermicompost by the action of earthworms generally include macro-micro nutrients, growth regulating hormones, growth promoters and regulators, plant immobilized microflora, cellular components degrading enzymes (lipase, chitinase, amylases, proteases and cellulose) (Figure 5) and these enzymes further degrade the organic substrates even they are secreted from earthworms (Rehman *et al.*, 2020). These growth promoters, regulators, *i.e.* (Figure 5 and 6) proline, glycine betaine, ascorbic acid, salicylic acid (Ahmad *et al.*, 2019) *etc.* nutrients *i.e.* nitrogen, potassium, phosphorus, calcium, magnesium, iron *etc.* are helpful to plants survive under drought stress conditions (Ahmad *et al.*, 2019; Ali *et al.*, 2018). Earthworms modify the physical and chemical status of organic substrates, slowly alleviating the C:N ratio of organic matter, enhancing the surface area exposed to microbes and creating it more promising for microbial action for further degradation. The organic matter, structure, texture, pH, is improved by vermicompost addition. It also maintain various positive environmental factors like soil temperature and moisture (Kilbacak *et al.*, 2021). The movement of fine organic frictions and bacteria- excrements in the gut of earthworm therefore will lead to the homogenization of organic substrates. The final product of vermicompost is a fine fractionalized humus like organic material having high water-retaining capacity and porosity that includes essential nutrients and minerals such as ammonium and nitrate which are easily accessible to plants (Aslam *et al.*, 2020).

### 1.4 Vermicomposting procedure and process

The following (Figure 3 and 4) illustrate the vermicomposting procedure and process;

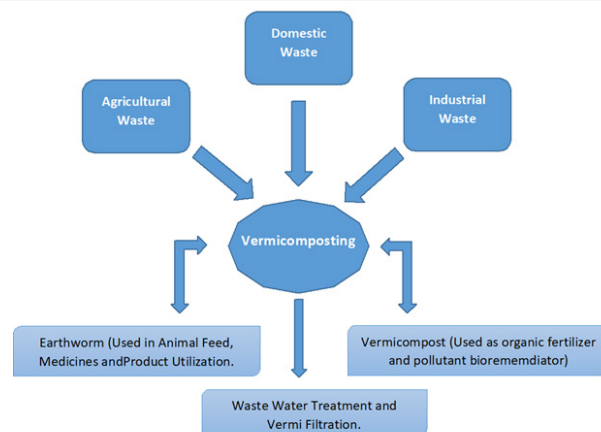


Figure 2: Vermi-technology.



Figure 3: Vermicomposting procedures (A) Collection of Materials, (B) Crushing of materials, (C) Pre-composting, (D) Watering.

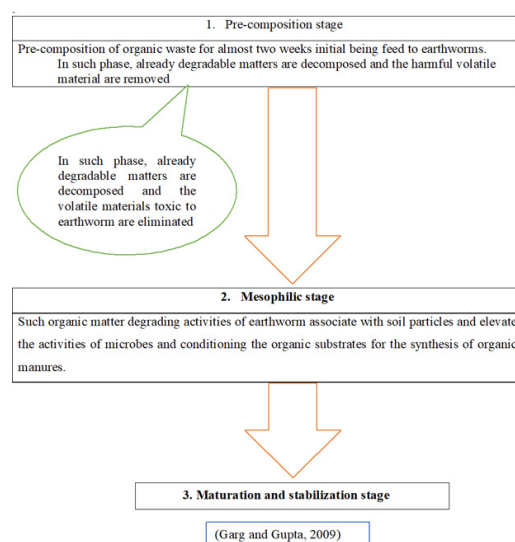


Figure 4: Illustrate the vermicomposting process.



**Table 1: Earth worm's ecological classification, ecological interaction, characteristics and advantageous features.**

Earthworm species	Ecological classification	Ecological Interaction	Characteristics	Advantageous features
<i>D. octaedra</i> , <i>Bimastus minusculus</i> , <i>Dendrobaena veneta</i> , <i>Dendrodrius rubidus</i> , <i>B. eiseni</i> , <i>Lumbricus spp</i> , <i>Eiseniella tetraedra</i> and <i>Eisenia foetida</i>	Epigeic species	found in superficial soil layers, compost and leaf litter	Smaller in size, body uniformly pigmented, active gizzard, short life cycle, high reproduction rate and regeneration, tolerant to disturbance, phytophagous	Effective compost producers, assists in litter pulverization and early decomposition, efficient bio-degraders and nutrient releasers
<i>Aporrectodea. rosea</i> , <i>A. caliginosa</i> , <i>A. trapezoids</i> and <i>Millsonia anomala</i>	Endogeic Species	Dwell in upper soil and sub-soil	Large to small in size, less pigmented body, geophagous, life cycle of medium period, fairly tolerant to disturbance	
<i>Octolasion lacteum</i> and <i>O. cyaneum</i>	Endogeic and Polyhumic species	Upper soil, type (A1)	Non-pigmented body, small in size, rich soil feeder, burrowing horizontally in soil	
<i>Allolobophora chlorotica</i> and <i>Pontoscolex corethrurus</i> ,	Endogeic and Mesohumic Species	(A and B horizon) soil layers	Non-pigmented body, medium in size, create intensive horizontal burrows in soil, feed on bulk soil (A <sub>1</sub> )- type	
<i>Aminthas</i> sp	Endogeic and Oligohumic Species	(B and C horizon) soil layers	Very large in size, unpigmented, forms intensive horizontal burrows, feeds on poor, deep soils	
<i>A. longa</i> , <i>L. Polyphemus</i> and <i>L. terrestris</i> ,	Anecic species	Extensively burrow in soil	Pigmented at dorsal portion of the body, larger in size, less reproduction rate, nocturnal, phyto-geophagous extensively form vertically deep permanent burrowing holes in soil	Involve in blending of soil nutrients

(Kooch and Jalilvand, 2008; Pathma and Sakthivel, 2012).

**Table 2: Reveals the nutrients concentration found in vermicompost.**

Nutrients	Quantity
S	128.0 to 548.0 mg kg <sup>-1</sup>
Zn	5.7 to 9.3 mg kg <sup>-1</sup>
Fe	2.0 to 9.3 mg kg <sup>-1</sup>
Cu	2.0 to 9.3 mg kg <sup>-1</sup>
Ca and Mg	22.67 to 47.6 (Meq/100 g)
Na	0.055 to 0.3 %
P	0.1 to 0.26 %
K	0.15 to 0.256 %
N	0.5 to 0.9 %
C	9.15 to 17.88 %

Garg and Gupta, 2009.

### 1.5 Chemical composition of vermicompost

Vermicompost is a mulch related organic matter including utmost minerals and nutrients which are already available to plant such as Ca, K, PO<sub>4</sub><sup>2-</sup> and NO<sub>3</sub><sup>-</sup> ions etc. This organic manure has great water

holding capacity (WHC), porosity and large surface exposure area, which is responsible for providing adequate sites for microbial functionality as well for retaining of essential nutrients. The production of plant growth regulating hormones for instance, cytokinins, auxins and other mulch materials are achieved from microbial activities are found in vermicomposts. (Table 2 and 3).

## Conclusions and Recommendations

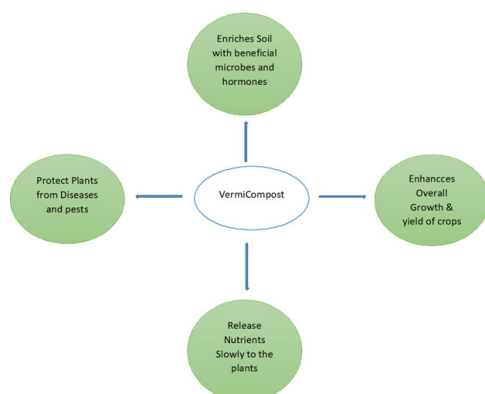
It can be concluded from this study that vermicompost is the process of conversion of waste in to black gold that contains digestive enzymes such as amylase, cellulase, protease, lipase, chitinase and urease, macro and micro nutrients *i.e.* nitrogen (N), phosphorus (P), potassium (K), iron (Fe), zinc (Zn), sulphur (S), growth promoters and regulators *i.e.* ascorbic acid, salicylic acid, proline, glycine betaine etc. that are helpful for plants to survive under stress conditions that may be drought, salinity, high temperature, chilling, pests and diseases.

**Table 3: Effect of vermicompost on agronomic traits of cereal crop.**

Cereal crop	Nutrient sources	Plant attributes	Country
Wheat	Vermicompost integrated with organic or inorganic fertilizers	Improvement in growth, reproductive, soil nutrient, physio-chemical and yield traits	Pakistan <a href="#">Aslam et al., 2019</a> <a href="#">Hussain et al., 2016</a>



**Figure 5: Vermicompost Chemical analysis, (A) Streking of bacteria's, (B) Cellulose degrading bacterias collected from earth worm's gut, (C) Inoculation of bacteria in vermicompost, (D) Dilution of vermicompost in water, (E) pH measurement, (F) Ec. Measurement.**



**Figure 6: Vermicomposting benefits.**

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## Novelty Statement

Vermicompost is complete and readily available nutrition for all crops. When vermicompost fully prepared then earthworms are used for feed of poultry and fisheries. No research work had done in Pakistan on this topic. Dr. Zubair Aslam, Associate Professor, Department of Agronomy, Faculty of Agriculture, University of Agriculture, Faisalabad, introduce this technology first in 2019. Now a days chemicals are deteriorating our environment and causing stresses in plants animals and humans. This organic way of nutrition for plants, birds and fisheries would be helpful for healthy lives. This technology is environment friendly, economically viable and socially acceptable for plant, fisheries and birds nutrition.

## Author's Contribution

AA, ZA, KB, MKM, NI, MI, MN, MYN, YA, TA, MAJ, AK, EU and MMA: Conceived and designed the experiment, performed the experiment, analyzed the data, contributed reagents/ materials/ analysis tools, wrote the paper.

## Conflict of interests

The authors have declared no conflict of interest.

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