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A Review on the Growing Threats to Earthworm (The Farmer's Friend)

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ABSTRACT: The importance of the earthworms in the agricultural practices is well known worldwide. They contribute in increasing the quality and fertility of agricultural soil. Earthworms provide key soil functions that favour many positive agro-ecosystem services. These services are important for agricultural sustainability but can be degraded now a day by intensive modern agricultural practices such as use of fertilizers, pesticides, herbicides and other toxic chemicals. Many literature reports have investigated the effect of pesticides, herbicides and other toxic chemicals on earthworms. This review tries to raise awareness among farmers and other peoples for the growing threats to earthworms, the impact of fertilizers, pesticides and chemicals on their soil farming activities and promotes sustainable and eco-friendly agricultural practices. The increasing use of pesticides and toxic chemicals in the agricultural lands has adverse effects on earthworms and the other soil fauna. Earthworms are important decomposers and exhibit a wide range of sensitive responses to environmental pollutants. They are commonly utilized as test organisms for environmental contaminations. Earthworms are incredible soil fauna playing an important role in maintaining soil health. Extensive use of pesticides, herbicides, insecticides and soil toxicants in crop management are known to be growing threats to earthworms.

Keywords: Agro-ecosystem, Fertilizer, Pesticide, Herbicide, Insecticide and Soil toxicant.

INTRODUCTION

Earthworms are the soil-dwelling terrestrial invertebrates that belongs to the phylum Annelida. They were classified into the order of Opisthopora since the male pores opened posterior to the female pores. Other common slang names for earthworms are dew-worm, rain worm, night crawler, and angleworm (due to its use as angling hook baits). Larger terrestrial earthworms are also known as megadriles (big worms). The megadriles are characterized by a distinct clitellum and a vascular system with true capillaries (Omodeo, 2000). Earthworms are the major terrestrial macrofauna, constitute more than 80% of the soil invertebrate biomass (Senapati and Dash 1981; Sorour and Larink 2001). Earthworms are commonly found in moist, nutrient-rich soil, eating a wide variety of organic matters which include detritus living protozoa, rotifers, nematodes, bacteria, fungi and other microorganisms. An earthworm's digestive system runs the length of its body. They are the most important detritivores and coprophages in nature and also serve as food for several lower vertebrates (Bonkowski *et al.*, 2000; Edwards and Lofty 1977).

Earthworms have an externally segmented tube-like body with corresponding internal segmentations (Metameric segmentation) and usually have setae on all segments (Edwards and Lofty 1977). Double transport system is present which is made of coelomic fluid that moves within the fluid-filled coelom and a simple, closed circulatory system. They generally respire by their lubricated skin, called cutaneous respiration. As soft-bodied invertebrates, they lack true external as well as internal skeleton. The structure and shape of the body are maintained by fluid-filled coeloms that function as a hydrostatic skeleton. Earthworms have a central nervous system consisting of two large ganglia (Brain) above the mouth, one on either side, connected to an axial nerve running along its length to motor neurons and sensory cells in each segment. Large numbers of chemoreceptors are located near its mouth. Circumferential and longitudinal muscles running each segment let the worm to perform its locomotion. Similar sets of muscles line the gut tube and their actions propel digested food toward the worm's anus (Cleveland *et al.*, 1984). Earthworms are hermaphrodites because they have both male and female reproductive organs and genital pores. When mating, two different earthworms will exchange their sperms and fertilize each other's ova.

Earthworms are also categorized on the basis of their behavioural, morphological and physiological adaptations that enable them to screen available resources in the soil. The three main morpho-ecological categories of earthworms have been reported, called as epigeic, anecic, and endogeic (Bouche, 1977; Lee, 1985; Edwards and Bohlen 1996).

EPIGEIC: These are soil surface dwelling earthworms which feed on plant litter. They dwell on the soil surface or within the litter layer of the soil. These are usually heavily pigmented earthworms as they are constantly exposed to sunlight. Their size ranges from small to large. Examples: *Eisenia fetida, Eisenia andrei, Eudrilus eugeniae, Perionyx excavatus* and *Drawida modesta*.

ANECIC: These are top soil dwelling earthworms which feed on plant litter and soil. They usually live in vertical permanent burrows. They are dorsally pigmented and large. Examples: *Lampito mauritii* and *Octochaetona serrata*.

ENDOGEIC: They are deep burrowing earthworms and are humus and soil feeders. They usually live in extensive horizontal burrows. They are not heavily pigmented and size ranges from small to large. Examples: *Octochaetona thurstoni*, *Allolobophora longa*. Endogeic earthworms have been further subcategorized into polyhumic, mesohumic and oligohumic groups on the basis of their importance of organic rich mineral soil in their diet and increasing size. Polyhumic endogeic earthworms like to live in and feed on high organic rich mineral soil. Mesohumic endogeic earthworms like to live in and feed on soil containing moderate amount of organic rich minerals. Oligohumic endogeic earthworms like to live in and feed on soil containing very amount of organic rich minerals.

Out of these three groups of earthworm species, epigeic earthworms have greater capability of degrading organic wastes and endogeic earthworms have better capability for protein conservation and soil turnover, whereas anecic earthworms have capability of both groups (Dash and Senapati 1980).

SPECIES OF EARTHWORM

Reynolds (1994) recorded the occurrence of 3,627 terrestrial earthworm species worldwide. The earthworms are well reported fauna in India as compared to other Asian Countries. About 452 valid species/subspecies of earthworms under 71 genera are reported from the Indian Territory, including its Islands. The first earthworm species in the Indian subcontinent was reported by Templeton (1844) when he discovered *Megascolex coeruleus* from Sri Lanka. The most diverse families of earthworms in India are Megascolecidae comprise 191 species of 19 genera; Acanthodrilidae with 123 species of 26 genera and Moniligastridae with 89 species (all native) of 3 genera. The most diverse genera of earthworm in India belong to *Drawida* (74 species) and *Moniligaster* (14 species) of family Moniligastridae; *Perionyx* (51 species), *Megascolex* (32 species) and *Argilophilus* (23 species) of family Megascolecidae; *Eutyphoeus* (27 species), *Haplochaetella* (19 species) and *Octochaetona* (15 species) of family Acanthodrilidae (Earthworms of India).

ECONOMIC IMPORTANCE OF EARTHWORM

Earthworm are the most important soil fauna which develop and maintain the nutrient and mineral value of soil by converting biodegradable materials and organic wastes into nutrient rich vermicompost (Jansirani *et al.* 2012). They are also called as ecological engineers (Jones *et al.*, 1994). Their distribution and abundance depend on several ecological factors such as soil status, nutrients, temperature, moisture, season, adequate dissolved oxygen, pH and the presence of fertilizers and pesticides (Lee, 1985; Bhaskaran, 1986; Morgan, 1993; Viswanathan, 1997; Curry, 1998; Bhattacharjee, 2002). Therefore, earthworms are found in broad range of soil and play an important role in deposition of about 60%-80% of the total soil biomass (Luo *et al.*, 1999; Sizmur and Hodson 2009). They are the most important natural fauna in the terrestrial ecosystem which significantly regulate various processes such as soil formation, organic matter breakdown, decomposition process and nutrient-mineral recycling. Indian earthworms that are currently utilized for vermicomposting of organic wastes are *Perionyx excavatus*, *Lampito mauritii*, *Dendrobeena repaensis*, and *Metaphis hovlleti* (Kaushal *et al.*, 1999).

Earthworms are capable to consume a wide range of unstable and biodegradable organic matter such as domestic waste, animal faeces, industrial waste, sewage sludge etc. The feeding and burrowing activity of earthworms increase the decomposition of organic matter, formation of humus, and development and maintenance of soil fertility.

Earthworms help in soil development, soil turnover, increasing the soil aeration, water permeation and water holding capacity of soil, maintenance of the soil fertility and formation of the productive soil. Earthworms contribute in the soil forming process by five ways such as by altering soil pH, by causing physical and chemical decomposition of organic matter, by humus formation, by improving soil texture and by enriching the soil with nutrients and minerals. Earthworms are ecosystem engineers and capability for changing the physical, chemical, and biological properties of soil. Vermicompost obtained by decomposition of organic waste through earthworm's gut is quite different from its parental waste material and popularly known as **black gold** (Lim *et al.*, 2015b; Patangray, 2014). It boosted the practices of organic farming all over the world. Earthworms also enhance the physical properties of soil such as hydraulic conductivity, porosity, bulk density, infiltrability, aggregate stability etc. (Devkota *et al.*, 2014). Earthworms improve nutrient availability by ingesting organic residues of different carbon and nitrogen ratios (Patnaik and Dash 1990). Activities of earthworms also help in enhancing beneficial soil microbes. The mucus secretion and excretion from the gut of earthworm are known to enhance the activity of soil microorganisms (Bhaduria and Saxena 2010).

Therefore, earthworms play the beneficial role for soil ecosystem by maintaining soil structure and fertility. They affect the dynamics of organic matter, soil texture and microbial fauna in soil. They also increase the porosity of soil by altering the physical and chemical properties of soil organic matter and by mixing plant leaf litter with soil to form and stabilize soil aggregates. The faecal castings of earthworms nourish the agricultural land with several nutrients and minerals. They increase nutrient and mineral contents of the soil biologically such as nitrogen, phosphorus and potassium. Earthworms help in recycling of nitrogen through their faecal matter, especially in shifting cultivation (Bhadauria and Ramkrishnan 1996). Earthworms are the "natural ploughman" because they soften the soil when they make their burrows in soil. By doing so, they increase the aeration of the soil that make the soil better for crop plants to grow. Earthworms participate in the biogenic transfer of soil materials in different soil strata. All of these are important activities of earthworms for the maintenance of soil health and are essential to soil ecology and agronomy (Feller *et al.*, 2003). Earthworms are usually found to live in different soil strata. Epigeic earthworms feed on the dead and decaying leaf litter and play important role in both consumption and formation of humus. Endogeic earthworms make horizontal tunnels and actively aerate the soil that helps in the growth of plant roots while anecic earthworms make vertical tunnels and release their faecal castings on the surface of the soil regularly that increases the fertility of the soil. The collective effect of rain, vegetation and earthworm's faecal castings cause compaction and decomposition of soil which aids in pedogenesis (Lavelle, 1988). Earthworms can play an important role to the migration of pollutants in the soil (Kuzyakov and Blagodatskaya 2015). These incredible services provided by the earthworms to the terrestrial ecosystem as well as agriculture, are now a days under the threats and this book chapter is mainly focused on understanding the economic importance of earthworms and their growing threats.

THREATS TO EARTHWORM

The economic importance of earthworms in agricultural practices and soil ecosystem is well known all over the world. In recent years, the growing use of chemical fertilizers, pesticides, herbicides and toxic chemicals in agricultural lands have adverse effects on soil flora and fauna. Earthworms which are popularly known as "Ecological Engineers" are reported by recent studies to be under threats due to such polluted environment. The major threats to earthworm population undoubtedly are the chemical fertilizers, pesticides, herbicides and toxic chemicals that are excessively used now a day for increasing agricultural crop production. After green revolution in India, the chemical fertilizers and pesticides were frequently used by farmers to increase their agricultural crop production. The excess use of chemical fertilizers and pesticides leads to soil, surface and ground water pollution that adversely affect to the soil flora and fauna along with non-target organisms, mainly earthworms. The growing use of chemical fertilizers and pesticides has been reported to exert severe adverse effects on soil building process and soil fertility.

According to some reports, chemical fertilizers, pesticides and toxic chemicals have harmful effects on earthworm at various levels of body organization such as change in morphology and behaviour pattern, metabolism and enzymatic activities, increase mortality, reduce fertility, obstruction in growth and reproduction (Pelosi *et al.*, 2013). Earthworm population is very sensitive to these chemical fertilizers and pesticides. Therefore, earthworms are used as bio-indicator species for the checkup of soil health as well as ecosystem health. In a study, Jeyaprakasam *et al.* (2021) found that the earthworm population was higher in uncontaminated soil as compared to pesticide-contaminated soil.

Fig. 1. Excess use of pesticides in agriculture.

Fig. 2. Death of earthworms due to pesticides.

Earthworms are highly sensitive to changes in ecological factors, essential to the soil and the activity of earthworms reflects soil pollution. Chemical fertilizers, pesticides, insecticides, herbicides and fungicides are now the essential components for the agricultural practices and crop production in the modern world (Stephan *et al.*, 2011; Pimentel *et al.*, 2011). The use pesticides in Indian agriculture are increasing year by year after the green revolution. Pesticides use per unit area is the highest in cotton crop followed by vegetables and rice (Peshin, 2014). Earthworms are unable to perform their important and vital roles in the soil ecosystem as they are exposed to various pesticides (Rathore and Nollet 2012). Some studies reported the weight loss of earthworms due to their exposer with pesticides such as acetochlor and

methamidophos. The earthworms exposed to contaminated soil (DDT), have greater rates of mortality, growth inhibition rates, low enzymatic activities (Shi *et al.*, 2016). Pesticides have harmful effects on the cocoon formation and their hatchlings, the survivability of newly borne earthworms and sexual development and reproduction of earthworms. Some pesticides like Dimethoate (an organophosphate insecticide) have harmful effects on the protein profile, cellular enzyme system and testicular histomorphology of earthworms (Mosleh *et al.*, 2003; Lakhani *et al.*, 2012). In recent years, soil pollution has increased due to the extensive use of inorganic chemicals, fertilizers and pesticides in agriculture (Kavitha *et al.*, 2020). The extensive use of these inorganic chemicals, fertilizers and pesticides has depleted soil fertility, eliminated beneficial microbes and adverse impact on the human health and the environment (Yatoo *et al.*, 2021).

CONCLUSIONS

Earthworms are "**Ecological Engineers**" as they involve in soil building, soil turnover, increasing soil aeration, increasing porosity of soil and its water holding capacity, maintenance of soil fertility. They are also known as "**Natural Ploughman**" and "**Farmer's Friend**" due to their crucial roles in soil ecosystem. Fast growing human population all over the world, especially in developing countries such as India and China, has forced to increase production of more food. To obtain high yields of food crops and protect the agricultural crops from various plant diseases, a large number of chemical fertilizers, pesticides, herbicides and fungicides have been employed in modern agricultural practices. After green revolution in India, the use of these chemical fertilizers and pesticides has been increased manifold. Several ecological and environmental issues have been raised from the usage of chemical fertilizers, pesticides, herbicides, fungicides and other toxic chemicals in modern agricultural practices. The soil fauna along with human population have also threatened. The excess use of chemical fertilizers and pesticides gradually eliminated the earthworm population in the soil. In the near future, loss of soil fauna and earthworms reduce yields of agricultural crops due to infertile soil. There are a lot of evidences that these chemical compounds have harmful effects on earthworm population. Chemical fertilizers and pesticides were employed with an intention to protect the growing human population all over the world by boosting agricultural crop production and reducing plant diseases outbreaks while their harmful effects on the environment and wild flora and fauna were totally ignored. Due to this ignorance, the important soil fauna, earthworms are now in danger. Hence, to protect and conserve soil fauna and earthworm population, government should make policies for promoting organic farming on a large scale. We should aware the farmers and villagers to avoid the usage of these harmful chemical fertilizers, pesticides, herbicides and fungicides. We should encourage the application of organic fertilizers (vermicompost) and organic pesticides to protect the real worm of the earth.

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