ORGANIC FARMING WITH EARTHWORM (*EISENIA FOETIDA*)

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Abstract:

Organic Agriculture is an sustainable alternative to conventional system as it aids in environmental Protection, improved food quality and human health. It has been estimated that to feed a world population of 2700 million people, 1100 million tones of food is required which works out to a demand of 100 million tones of fixed nitrogen. Chemical technology can contribute only million tonnes, legumes 5 million tones and precipitation 10 million tones to the world soils, leaving a large deficit. Large quantities of nitrogen are lost as sewage and rubbish. This loss is of the order of 4-5 million tones of nitrogen almost equivalent to the quantity added as nitrogenous fertilizers. About 4000 million acres of cultivated land in the world is likely to suffer a loss of atleast 50 million tones of nitrogen per year in crop production. These losses can be compensated in permanent agriculture only through natural methods of recuperation. Earthworms can thus perform an important function by providing fertilizers from waste. The species commonly supplied by earthworm farms, namely Eisenia foetida. The major contribution of earthworms seems to be in breaking up organic matter, combining it with soil particles and enhancing microbial activity when humification is well advanced. Vermicomposting is a green technology that converts organic wastes into plant available nutrient rich organic fertilizer. It also increases soil structural stability and reduces vulnerability of soil to calamities like erosion. There has been considerable evidence in recent years regarding the ability of vermicompost to protect plants against various pests and diseases and so it is one of weapon used against continued application pesticides.

Key words: *Eisenia foetida, Earthworm, Vermicomposting, Organic farming*

Introduction:

Rapid growth of urbanization and industrialization has led to generation of large quantities of wastes. Millions of tons of municipal solid wastes generated from the modern society are being added to lands everyday creating extraordinary economic and environmental problems for the government to manage and monitor them for environmental safety. Similarly, the global usage of pesticides has increased considerably during the second part of the 20th century. In India, chemical agriculture triggered by widespread use of agro-chemical in the wake of “green revolution” of the late 1960s came as a “mixed-blessing” rather a “curse in disguise” for mankind. It dramatically increased the food grain production but severely reduced its “nutritional quality” and also the “soil fertility” over the years. The soil has become addict and increasingly greater amount of chemical fertilizers are needed every year to maintain the soil fertility and food productivity at the same levels. Increased use of agro-chemicals has virtually resulted into “biological droughts (decline beneficial soil microbes and earthworms) in soils. Soil and water pollution due to seepage and drainage especially after heavy rainfall were other ill-effects on farmlands following the use of agro-chemicals. The farmers today are caught in a “vicious circle of higher use agrochemical to boost crop productivity at the cost of declining soil fertility. This is also adversely affecting the economy of the countries as the cost of agrochemicals has been rising all over the world. Besides agricultural development has contributed to global warming, reduction in biodiversity and soil degradation. In view of the above, the recent years, much attention has been paid to manage different organic wastes resources at low-input as well as eco-friendly basis. Organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent, feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral, grade rock additives and biological system of nutrient mobilization and plant protection. Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological hormony. The web of life is perfect in organic farming and earthworm has a great role to play in this; be it cycling of nutrients, micro-flora and fauna population.

Earthworms are hermaphrodites. Each worm has both male and female organs. They are small tube like organisms who tirelessly work to turn the earth from lowest strata of earth to top. Worms tunnel deeply in the soil and bring subsoil closer to the surface mixing it with the topsoil. This makes the formation of multitude of linear tunnels minute in diameter but deeper below the subsurface. These tunnels facilitate infiltration of water into subsurface, reduce runoff, help in harvesting rainwater. In this process of tunneling it also maintains the soil structure and enables the process of aeration. This act makes earthworm as a real farmer who toils day long tilling the fields. Thus earthworm facilitate improving soil fertility and deposits on the surface. Their role gains significance because they convert larger organic matter into simple accessible form.

Earthworms are invertebrates belonging to the Phylum Annelida and Class Oligochaeta. Earthworm is a metamerically segmented worm-like animal. Earthworms are long, thread-like, elongated, cylindrical, soft bodied worms with uniform ring like structures all along the length of their body. The bodies consists of segments, arranged in linear series and outward by highlighted by circular grooves called annuli. Body segmentation is not only an external feature but it exists internally too. On the ventral surface of each segment are four pairs of short, stubby bristles or setae. The setae provide traction for movement. Earthworms have an opening at each of its ends, the opening at the anterior end is the mouth and the one at the posterior is the anus. Earthworms does not have any specific organ of sight, hearing or olfaction, but special cells exist all along the length of the body to take up these sensory function. Earthworm is almost terrestrial and burrows into moist-rich soil, emerging at night to explore its surroundings. In damp weather it stays near the surface, often with mouth or anus protruding from the burrow, while during dry weather, it burrows to several feet underground, coils up in a slumber chamber and becomes dormant. Earthworms are found in most part of the world with the exception of deserts (where they are rare), areas under constant snow and ice, mountains ranges, area bereft of soil and vegetation. Earthworms of the genus Pheretima, which are indigenous to South-west Asia, have also migrated to many tropical, subtropical and even temperate regions. Several peregrine species have their origins in South and Central America, and the West Indies; three of these species are now widely distributed in India like *Pontoscolex corethrusus, Endrilus eugeniae and Microscolex phosphoreus.*

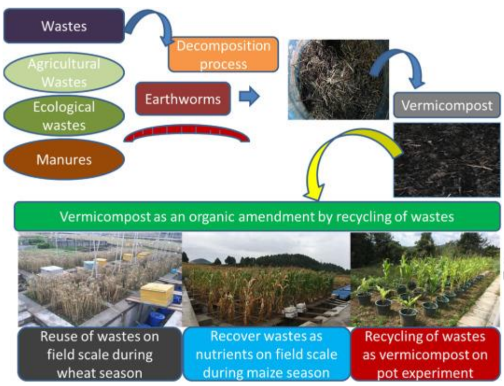
The activity, metabolism, growth, respiration and reproduction of earthworms are all greatly influenced by temperature. Fertility is affected very much by different temperature; for instance, the numers of cacoons produced by *A. caliginosa* and certain other lumbricid species quadruple over the range 6-16 degree C. (Evans and Guild 1948). The growth period from hatching to sexual maturity is also dependent on temperature, for instance, *A. Chlorotica* takes 29-42 weeks to mature in an unheated cellar (Evans and Guild 1948), 17-19 weeks at 15 degree Celcius (Graff 1953) and 13 weeks at 18 degree celcius (Michon, 1954).

The earthworms does not have specialized locomotory organs. It has circular muscles that wrap around both the body wall and the digestive tract. It also has longitudinal muscles that run between the anterior and posterior ends in both the body wall and the digestive tract. When the longitudinal muscles contract, they carry the earthworm forward by shortening its body length. When the circular muscle contract, bulges are formed along the length of the earthworms. The interaction of these two sets of muscles can produce a series of wave like movements. Earthworm move at the rate of about 15 cm per minute. The passage of soil through the earthworms gullet greatly promotes bacterial growth. In particular, actinomycetes, bacteria that create humus, thrive in the presence of earthworms. Through their constant burrowing, mixing and digesting, earthworms significantly improves the composition of the soil i.e. turn organic wastes into fertilizer and garbage into soil nutrients. Soil rich in earthworms remain loose, giving the soil a much better capacity to retain air and water.

Result:

Earthworms provide multitude of services for farmers. Earthworms are great “Soil engineers. As they move through the soil, earthworms loosen and mix it up, helping it to aerate and drain it. This brings nutrients to the surface, making the soil more fertile and helps prevent flooding and erosion. Earthworms activity in the soil stimulates the bacteria and other microorganisms that live in healthy soil. They really help in farm productivity. That is why they are known as farmer's best friend.Organic farming can be defined as an agricultural process that uses biological fertilisers and pest control acquired from animal or plant waste. Organic farming was actually initiated as an answer to the environmental sufferings caused by the use of chemical pesticides and synthetic fertilisers. In other words, organic farming is a new system of farming or agriculture that repair, maintains and improves the ecological balance. Today's conditions, the organic farming are very needed because excessive use of chemical fertilisers, reduces the fertility of soil. Excessive use of chemicals has led to soil, water and air pollution. Organic farming is more labour intensive. Hence, it generates more employment. It is Environment-friendly and promotes sustainable development. It is inexpensive farming and conserve ecosystem. It protect the environment, minimize soil degradation and erosion, decrease pollution, optimize biological productivity and maintain biological diversity within the system. Maintain long-term soil fertility by generating optimal conditions for biological activity in the soil. Recycle materials and resources and rely on renewable resources in locally organized agricultural systems. Sustainable agriculture means the production of food from plants or animals using different agricultural techniques that protect communities, the environment and animal welfare. The extensive use of chemical pesticides and fertilizers to boost crop yields may have resulted in good yields and productivity, but it has caused the efficiency of the soil to deteriorate throughout the world day-by-day. This modern agricultural practices has caused a steep fall in the biodiversity associated with cropland ecosystems.

Earthworms are one of the most important soil animals; they have the capability to maintain the fertility of the soil and therefore play a key role in sustainability. They are also known as **farmers friend, ploughman of the field, intestines of the earth, ecological engineers and biological indicators.** Earthworms are functionally very important and diverse and therefore potentially useful for the management of biodiversity and ecosystem services. Earthworms stimulate microbial activity, mix and aggregate the soil, soil water content water holding capacity. The mutual action of earthworms and microbes brings faster decomposition as the earthworms condition, aerate, fragment and enhance the surface area of the organic matter for microbial action.



Earthworms mainly feed upon the decaying organic matter found in the soil. They also feed on leaf and other plant material obtained on the soil surface. The food is first moistened by an alkaline enzymatic secretion which digests starch, making it easier to tear it into shreds. Leaves may be torn by holding them by the edge between the prostomium and the mouth and pushing the pharynx forward. Alternatively, small portions may be sucked in by first pressing the mouth against the leaf and then withdrawing the pharynx, thus creating suction. The food after reaching the pharynx get mixed; Pharynx has two chambers, the dorsal and the ventral. In the dorsal chamber, food is mixed with saliva, while the ventral chambers open into the oesophagus. From the pharynx, food enters into a narrow oesophagus and a crop where the food is stored for a short time. Now the soil and food enters a muscular gizzards. It is a hard muscular organ with thick muscular fibres. It has an internal columnar epithelium covered with a hard cuticle. The gizzard grinds the food with the help of thick muscles and cuticle. The hard particles in the soil help to grind the soft organic part. After the gizzard, it is followed by a short and tubular stomach. The glandular cells of stomach secrete a proteolytic enzyme which helps in digestion. After the stomach there is the intestine which is very thin walled and is extended upto the last segment. It opens out as anus. Finally the anus is an opening in the last segment, which opens to the outside to egest the faecal matter. Chemical analysis of earthworm castings shows that they can contain upto two times as much available magnesium, five times as much available nitrogen, seven times as much available phosphorous and eleven times as much available potassium as the surrounding soil. Ploughing by earthworms can go down to as much a three meters. It also breaks up the soil into smaller particles, thus significantly enhancing the surface area available for the absorption of moisture and nutrients. In the burrowing process, the soil's porosity also increases allowing more rain water to percolate downwards and recharge the groundwater level. Air too can enter the soil through the burrows, where it acts as an excellent insulator against temperature fluctuations on the soil's surface, (Lavelle P. (1988). Soil entering its mouth is constantly being processed by the inoculation of a mixed bacterial culture, and the grinding of rock particles to the size of a single micron. This processed soil is then excreted through the anus in the form of a manure that is known as "Vermicastings". Vermicastings are highly enriched kind of biofertiliser. Earthworms can thus be used very effectively to restore the fertility of degraded soil and wastelands.

Kitchen/organic wastes can be recycled into enriched vermicompost with the help of earthworms and they feed on these nutrient rich wastes, breaking them down into simple substances facilitating microbial action in the gut and ejecting out castings with high manurial value. The efficiency of vermicompost is due to the presence of several beneficial microbes and growth promoting substances in the vermicasts. Vermicompost exhibits increased cellulolytic and lignolytic activity, electrical conductivity, high amounts of plant nutrients like nitrates, ammonium ions, exchangeable cations like phosphorous and potassium and trace elements in forms quickly absorbable by plants (Ismail S.A. (1996). The strong aggregates of casts increase water holding capacity, infiltration and aeration. The castings of earthworms, which consists largely of digested soil and particles of organic matter is more chemically neutral than the surrounding soil. So by consuming soil, processing it and excreting the reminder as castings, sufficient number of earthworms help to keep a field close to the neutral PH. Soil that is excessively acidic or alkaline can inhibit the growth of plants and microbe, (Howard 1933).

Discussion:

Sustainable agriculture is one in which the goal is permantly achieved through the utilization of renewable resources. Basic elements of sustainable agriculture are conservation of energy, soil and water. Moreover it avoids the use of synthetic fertilisers, pesticides, growth regulators and live-stock feed additives. It is possible to effect a quick change-over to sustainable agriculture by harnessing vermiculture biotechnology to the soil. Soil improvement is very important to make use of even in the less productive land to increase food production. Mineral aggregates are more stable in the presence of organic particles and this is because the deficiency of the organic carbon hinders the retention of N, S and P in soil and their loss affects soil fertility (Russell E.J. 1910).

Earthworms affect the soil structure by ingesting the soil, partially breaking down organic matter, mixing these fractions and ejecting this materials as surface or subsurface casts. They also bring subsoil to the surface by burrowing through the soil. During these processes, they thoroughly mix the soil, form water stable aggregates, aerate the soil and improve its water holding capacity. The major contribution of earthworms to be in breaking up organic matter, combining it with soil particles and enhancing microbial activity when humification is well advanced. The final process in organic matter decomposition is known as humification, and this is basically the breaking down of large particles of organic matter into simple soluble forms of N, P, K and other mineral compound that can enter the soil to provide the nourishment for growing plant. Only about one-quarter of the fresh organic matter becomes converted to humus. Much of the humification process is due to smaller soil organisms, such as microorganisms, mites, springtails and other arthropods, but is also accelerated by the passage of the organic material through the guts of earthworms feeding on decomposed organic matter together with mineral soil, (Keup E. 1913). Probably some of the final stages of humification are due to the intestinal microflora in the earthworm's gut, because most of the evidence indicates that the chemical processes of humification are caused more by the microflora than by the fauna.

Earthworms that burrow deeply into the mineral strata and return, periodically the cast faecal material at the soil surface may facilitate the transport of certain elements to the surface litter from deep in the profile. There is abundant evidence that concentrations of exchangeable calcium, sodium, magnesium, potassium and available phosphorous and molybdenum are higher in earthworm casts than the surrounding soil. In addition to the physical mixing of the soil by burrowing activities soil enrichment is achieved by speeding up mineralization of organic matter 2-5 times by the earthworms. Earthworms ingestion causes an increase in surface area of the organic wastes. Earthworm burrowing enhances the oxygen penetration, microbial mineralization. The burrows can increase the soil volume from 8 to 30%. Soils with earthworms are reported to drain 4 to 10 times faster than the soils without earthworms. The water holding capacity of soil is said to increase due to the colloidal materials like earthworms mucus, which is an absorbing agent (Senapati and Dash, 1984). The root and shoot growth in direct-drilled barley plants increased significantly with the introduction of deep burrowing earthworms. Earthworms burrow may provide channels for root penetration and also improved root, growth because make a way for the infiltration of water along the nutrients to the deeper layers of the soil medium. Earthworm feeding increases the interaction among microflora, improving the flow and exchange of nutrients. In addition to nutrients, several valuable compounds are produced through the earthworm-microfloral interaction. These include vitamins (Such as B12) and plant growth hormones, such as gibberlins.

Agricultural researchers have shown that introducing large number of earthworms into agricultural land doubles the yield of wheat, increases the field of grass four times and multiplies clover yields ten fold. In experiments with millet, lima beans, soya beans and hay. Hopp (1949) also proved that the addition of live year earthworms increased yields much more than the addition of dead worms did, showing that it is the action of live earthworms, rather than just the nutrients in dead worms, that enhances soil productivity. Vegetables like tomato, cabbage, okra and brinjal grown on vermicompost have shown promising results, yielding quality vegetables than those grown using chemical fertilizers. Germination and flowering are also found to be much faster in vermicompost applied plots than in ordinary composted or uncomposted ones. This increase may attributed to the hormonal effect due to microbial action in vermicompost. Ornamental plant exhibit large, healthy leaves. Increased number of leaves per plant and leaf area is due to the effect of ammoniacal nitrogen present in vermicompost.

A comparatively new angle is the claim that certain beneficial chemicals are released from the bodies of earthworms which increase crop yields. Such substances have been detected in eight species of lumbricids and two megascolecids; they were secreted into the alimentary tract and voided with the faeces. Earthworms added to the soil in large numbers doubled the dry matter yield of spring wheat; the yields of grass and clover increased 4 and 10 folds respectively. The addition of live worms to a garden soil was reported to increase yield of peas and oats by 70% (Kahsnitz, 1922). The growth of oat seed-lings in brown podsol soil that had been treated with *Eisenia foetida* for 8 days with that in the same soil without worms has been compared. The dry matter yield of the oat seedlings was 7-8% greater in the soil with earthworms and the total protein yield was 21% more.

Field experiments in New Zealand showed that the addition of European species of earthworms to sown pastures can increase crop yields. The soils were usually acidic; so lime was added to counteract this and then colonies of about 25 individuals of *A. caliginosa* were added, 4 years later, around each inoculation point there was a greener and more densely covered area, several meters in diameter. After 8 years, the areas of earthworm activity had spread as far as 100 m from the initial inoculation point (Hamblyn and Dingwall 1954; Richards 1955, Stockdill 1959). A few studies have been made on the effect of earthworms on the growth of forest trees. There was an increase in the growth of two-years old seedlings of oak (*Quercus rober*) by 26% and of green ash (*Fraxinus pennsylvanica*) by 37%, when live earthworms were added to the pots (Zrasheyski 1957). Black spruce (*Picea marnand*) seedlings showed significant increase in weight when the earthworms were added to the soil in which they were grown (Marshall, 1972).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Vermicompost or in general organic fertilisers are better than chemical fertilizers in economical and ecological aspects. Replacing costly yet deadly chemicals with cheap yet friendly vermicompost will ensure sustainable food production. Organic farming, of which vermicompost is a major package, use of vermicompost as manures has multi-folded benefits; healthy soil with soil organisms, limited external inputs, cost effective farming practices and healthy food. Moreover, problems of leaching and mineralization of nutrients are reduced. Plants are much healthier, with great degree of resistance to pests and diseases in addition to being fairly tolerant to drought conditions. Earthworms with their marvelous capability of ingestion, digestion and excretion are nature's most useful converters of waste.

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