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EARTHWORM CASTING – AN OVERVIEW

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For the last millions of years, earthworm castings were the richest and best of all known fertility improvers. Earthworm casting have many diverse functions beyond improving soil fertility. Annual cast production by different species and in different habitats are different and during monsoon it is highest in tropical countries. The casts may be of different forms *viz.* columnar, spheroid, pyramidal, granular, thread like and composite irregular aggregates. Earthworm castings have a variety of micro-and macronutrients which help in plant growth and the overall health of the soil. Each of the nutrients - especially nitrogen, potassium, and phosphorus - is essential to plant growth. Castings contain a multitude of living bacteria, fungi, and other microscopic organisms, which are beneficial to plants and soil environment. Suitable species such as *Eisenia fetida, Eudrilus euginae* and *Perionyx excavatus* are used in the process of waste conversion known as vermicomposting..

Key words : Casting, soil fertility, macro and micro nutrients, vermicomposting.

INTRODUCTION

Earthworms are so familiar to us that little description is needed. Earthworms have been around almost since the beginning of earth. Even during the age of the dinosaurs, earthworms were an important organism in the soil doing great service by converting organic waste into plant nutrients. Long before the invention of agricultural implements, earthworms were the incessant cultivator of our land and their castings were the richest and best of all known fertilizers. They were the main contributors to enriching and improving soil for plants and enriched the world's soil for millions of years, according to the Food and Agricultural Organization of the United Nations. The enormous contributions of the earthworm have not gone totally unrecognized during the long history of mankind. Value of earthworms in plant propagation was recognized by the ancient great Indian scientist Surpala in his epic 'Vriksha-ayurveda' (Science of Tree Growing) as early as in the 10th century A.D (Sadhale 1996). The Ancient Greeks considered the earthworm to have an important role in improving the quality of the soil. The Greek philosopher Aristotle (384 - 322 B.C.) referred to earthworms as "the intestines of the earth". The Ancient Egyptians were the first on record as recognizing the value of the earthworms played in the fertilization of the Nile delta; their queen Cleopatra (69 - 30 B.C.) enacted stringent laws protecting the earthworm for its useful toil of the Nile Valley. It was rightfully so, a 1949 study conducted by the USDA (United States Department of Agriculture) confirmed that the great fertility of the Nile soil was due in large part to the work of earthworms and their casting (Medany, 2011) . It was estimated that during the six months of active growing season each year the castings of earthworms on these soils amounted to a stunning 120 tons per acre, and in each handful of that soil are more microorganisms than there are humans on the planet The father of Evolution, Charles Darwin (1809 - 1882) was fascinated by earthworms. After forty years of studying them, he first showed that earthworms played the most important part in the history of the world as agent of soil formation and in maintaining the soil fertility.

The earthworms still enjoy the roll of one of the most important creatures on earth. At the 2011 conference, the Soil Association stressed the importance of the earthworm as the root of all biodiversity. The earthworm remains important by converting organic matter into rich humus or casting and improving soil fertility. Earthworm casting surprised researchers through their diverse functions beyond improving soil fertility. The following will help us to understand earthworms and its casting and how we may be able to benefit from earthworm casting.

What are earthworm Castings

Worm castings are worm excrement. Worm castings are the material excreted by the earthworm after organic material passes through the digestive track of the worm. Essentially, we can call it worm manure, or worm humus. Worm castings are not actually compost. The vermiculture process produce vermicompost. The excreted worm cast is reported to contain high amounts of mineral nutrients, vitamins, plant growth hormones, proteins and enzymes.

Earthworms eat animal manures, leaf litters, green waste, household refuges, bio-solids (human sewage), waste from agricultural based industries etc. - any living being that is decaying. The digestive process adds a complete array of biological organisms to the castings. These organisms include beneficial bacteria, fungi, actinomycetes, pseudomonads, plant growth regulators, yeasts, and molds. As many as 10,000 different biological species are added. Worm castings, neutralized by constant additions of carbonate of lime from three pairs of calciferous glands near the worm's gizzard, and finely ground prior to digestion, are five times as rich in available nitrogen, seven times as rich in available phosphates, and eleven times as rich in available potash as anything else in the upper six inches of the soil, producing a nutrient in just the right condition and proportion for the plant to absorb (Colombo Herald, Sept. 26, 2010). These organisms provide conversion mechanisms so plants can access needed nutrients.

1 2

Figs. 1-2 : Worm casts; **1.** *Metaphire posthuma*; **2.** *Eutyphoeus* sp.

Based on preceding reports, earthworms can consume 2 to 5 times its body weight and only uses 5 to 10% of nutrient from the feed stock for its growth (Sharma *et al.*, 2005). The rest is excreted out in the form of fine mucus coated granular aggregates

called castings which are rich in NKP (nitrates, phosphates and potash), micronutrients and beneficial soil microbes.

An earthworm is said to produce its own weight in castings each day it is on the prowl. Henry Hopp of the USDA estimates that one acre of good agricultural land can produce well over five tons of castings in a year, or more than 5 percent of the total soil volume to plow depth. In the process of producing its castings, on even an ordinary agricultural soil, earthworms are credited with turning more than fifty tons of soil per acre, and in the Nile Valley as many as two hundred tons, into a fructifying base.

Darwin (1881) estimated that the annual production of worm casts in English pastures was 18.7-40.3 tonnes per ha (7.5-16.1 tons per acre), which is equivalent to a soil layer 5 mm deep being deposited annually. Guild(1955) calculated that 27 tonnes per ha were produced in another English pasture. Similar estimates for the amount of cast deposited per annum in other parts of Europe range from 5.0-7.5 tonnes per ha for Germany (Kollmannsperger, 1934) to 75-100 tonnes per ha for Zurich (Stöckli, 1928). In the tropics, castings reported 50 tonnes per Ha in Ghana (Nye, 1955), 2100 tonnes per Ha in Cameroons (Kollmannsperger, 1956) and 2600 tonnes per Ha in the Nile valley (Beauge, 1912; Edwards & Lofty, 1972).

Amount of cast produced can serve as an index for assessing earthworm activity. Immediately after rains, release of surface casts will be at a maximum level. At this point of time, majority of earthworms are found at 0 to 10cm depth and very few of them are found at 20 to 30cm depth. In general, cast production in tropical countries is restricted to wet seasons. Norgrove & Hauser (1999) have recorded around 30 to 35 T/ha of cast production in tropical silvicultural system. Reddy (1983) has reported annual production of 23.4 to 140.9 T/ha by *Amynthes alexandri*. According to Lavelle (1974), cast production is rhythmic and it will be at maximum at early morning hours.

Casting – Shapes and Forms

After passing through the animal, the food emerges as a compact, concentrated mass termed as casting. Worm casts help to aerate the soil and hold water due to their unique shape, which helps root growth immensely. At the same time, shape of the casts allow for excellent drainage in soil so roots don't become waterlogged or develop root rot. Some species cast within their burrows and others on the surface. Epigeic earthworms deposit their castings exclusively on soil surface. There are very many different forms of casts which are often typical of the species that produced them. The form of casting may vary from individual tiny, loose ball-shaped pellets (as in *Metaphire posthuma*) to short threads or rods (as in *Perionyx milardi*) (Gajalakshmi & Abbasi, 2004) The casts may be of different forms *viz*. columnar, spheroid, pyramidal, granular, thread like and composite irregular aggregates. The castings of *Eudrilus eugeniae* may be granular or spindle like masses that may be 2 to 3cm high heaps (Kale & Karmegam, 2010).

Perionyx excavatus deposits castings in the form of short threads or rods (3-5 mm length and 1-2 mm dia). Castings of *Bimastos parvus* deposits casting in the form of small spheroidal to spindle shaped. *Lampito mauriti* releases casting on soil surface in the form of small heaps of spheroical or nearly globular pellets. *Metaphire houlleti*

deposits casting in the form of cords, scattered or low piles. Casting of *Lennogaster pusillus* are in the form of small towers. *Polypheretima elongate* excretes casting in the form of cords of about 2 mm thickness and 20-24 mm length or in irregular piles 10-20 mm high and 20-35 mm width. *Glyphidrilus tuberosus* deposit casting in the form of elongated threads arranged in small tower like structures. *Dichogaster bolaui* deposits in small heaps of tiny globular pellets (Halder, 1998). Surface casts of *Eutyphoeus* are columnar (towers) with tubular convolutions or spherical aggregated units. Thick tubular convolutions are found in the large casts of *E. gammiei* (140-160 x 40-50 mm), *E. assamensis* (30-50 x 15-30 mm). Casts of *Metaphire posthuma* are deposited on the soil surface in the form of little heaves of individual spherical or sub-spherical pellets (2-3 mm). Granular casts of tiny (0.5 mm) and moderate size (1-2 mm) are produced by *D. boloui, D. modiglianii,* respectively (Chaudhuri *et al.*, 2012). Some worms excrete a long, thick column of feces which produces a hollow mound about 5 cm high and 2.5 cm in diameter. *Eutyphoenus waltoni*, an Indian species, produces casts that look like a twisted coiled tube and the African species *Eudrilus eugeniae* Kinberg produces casts that take the form of pyramids of very finely divided soil (Gajalakshmi & Abbasi, 2004).

Earthworm casts can be very large; those of European worms seldom exceed 100 gm, but African worms such as *Dichogaster jaculatrix* have casts in the red clay chimneys about 10-12 cm high and 4 cm in dia.(Baylis,1915). The giant *Notoscolex birmanicus* earthworms of Burma produce large tower shaped casts sizes 20-25 cm high and 4 cm dia; one such cast weighed 1.6kg after drying for four months (Gates, 1961) and *Hyperiodrilus africanus* produce large tower shaped casts sizes 2.5-8.0 cm high and 1-2 cm in dia (Madge, 1969). Both Madge & Gates (1961) agreed that casting by tropical species of earthworms is limited to wet season (Edwards & Lofty, 1972). Earthworm casts are most abundant during rainy season.

Casts as benefactors

Several universities have researched the benefits of worm castings, but specific knowledge by the general public and even trained agriculture scientists is still very limited. Earthworm castings have a variety of micro and macronutrients which help in plant growth and the overall health of the soil. These are slow-releasing nutrients staying in the soil for the whole season. Castings have the three essential macronutrients N-P-K (nitrogen, phosphorus, and potassium), as well as many micronutrients like calcium, potash, magnesium, zinc, iron, carbon, nitrogen, manganese, copper, and cobalt. Casts contain five times more nitrogen (nitrate), seven times more phosphorus, eleven times more potassium (potash), three times more exchangeable magnesium and one and half times more calcium than ordinary top soil, the main minerals needed for plant growth.

Earthworm casts contain microorganisms, inorganic minerals and organic matter in a form available to plants and the large numbers of beneficial soil micro-organisms in worm casts have at least as much to do with it. Casts contain nearly eight times as many micro-organisms as their feed. And these micro-organisms are that best favour healthy plant growth. Humus prevent the harmful effects of plant, pathogens, fungi and nematodes and unwanted bacteria. Pathogenic bacteria are reliably killed in the worms' gut. Wormcasts enriches soil with plant hormones such as *auxins* and *gibberellic acid.* Casts also contain enzymes such as protease, amylase, lipase, cellulose and chitinase,

which continue to disintegrate organic matter even after they have been excreted.

Castings act as a barrier to help plants grow in soil where pH levels are too high or too low. They prevent extreme pH levels from making it impossible for plants to absorb nutrients from the soil. The castings are always more acidically neutral than the soil from which they were formed. The casts are also rich in humic acids, which condition the soil, have a perfect pH balance, and contain plant growth factors.

Perhaps most importantly, castings contain a multitude of living bacteria, fungi, and other microscopic creatures. These creatures are beneficial to plants and soil environment. They create a more balanced environment and prevent harmful microbes from taking hold. This leads to protection against harmful fungal and bacterial plant diseases. Castings can even be used to help soil recover in a place where heavy chemicals have killed off most of the microbes. Even pest insects are repelled from plants treated with castings. The actinomycetes fungus excreted by the earthworms in their cast produce chemicals that kill parasitic fungi such as *Pythium* and *Fusarium.*

Worms stimulate high levels of beneficial and biologically active soil microbes. Earthworms hosts millions of beneficial microbes (including the nitrogen fixers) in their gut and excrete them in soil along with nutrients nitrogen (N) and phosphorus (P) in their excreta *i.e.* wormcast.

The worm casting are a good fertilizer additive for agricultural crops. Worm casts do not burn like chemical fertilizers, and stay in the soil longer. Nutrients in earthworm casting are released a little at a time. This is because they are surrounded by a mucus membrane, or oils. These membranes slowly wear away, and thereby take time to release the nutrients into the soil. Worm castings are completely odourless, and they are nontoxic and safe to use.

In worm casting, the NPK (Nitrogen, Phosphate and Potassium) are locked in the cast, and released into the plants slowly as micro-organisms break it down. This is much better for plants, as it takes time for plants to uptake nutrients rather than all at once. the NPK value in worm cast is much higher than soil. It is well established that worm casts are richer in 'inorganic phosphorus compounds' extractable in water than the surface soil ingested. Graff (1970) found that exchangeable phosphorus (P) measured isotopically was three times greater in wormcasts than in the underlying soils.

The texture of earthworm casting is also beneficial. Although it does help in increasing the soil's water retention capacity as they contain absorbent organic matter that holds only the necessary amounts of water needed by the roots. It also helps the soil around a plant drain excess water properly.

Nutrients in casting

Worm castings' nutrient content depends on the type of diet the worms have been fed with. As worms consume organic materials, they break them down and excrete them in their castings, producing compost rich in nitrogen, phosphorous, potassium and calcium and other micronutrients. To have an idea a typical nutrient analysis (a agricultural institute test report) of the percentages and composition of chemical nutrients and minerals in worm cast is given below:

- Carbon : Nitrogen (C:N) - 14-15 : 1 %
- Organic Carbon - 15 – 21 %
- Nitrogen - 1.5- 2.5 %
- Phosphorus (as P_2O_5)- 1.30 – 2.10 %
- Potassium (as K_2O) - 1.0– 1.80 %
- Calcium - 3.0 – 4.5 %
- Magnesium - 0.4 – 0.67 %
- Sodium - 0.02 – 0.50 %
- Sulphur - Traces to 0.30 %
- Iron - 0.3 – 1.0 %
- Zinc - 0.042 – 0.110 %
- Manganese - Traces to 0.40 %
- Copper - 0.0027 – 0.0123 %
- Boron - 0.0034 – 0.0075 %
- Aluminium - Traces to 0.071 %
- Cobalt, Molybdenum present in traces
- Moisture content – 75 – 80 %

The nutrient and mineral values of worm cast vary widely because the composition does truly depend on the type of feed is given to the worms. But from the above Table it is evident which kind of mineral and nutrient are more abundant within worm cast.

Suitable species for vermicomposting

Although worldwide more than 4,400 species of earthworms have been reported (Sinha, 2009) and in India 590 species of earthworms have been identified (Julka *et al.*, 2009), certain epigeic earthworms, with their natural ability to colonize organic wastes and digest and assimilate organic matter, high rates of feedstock consumption, tolerance of a wide range of environmental factors, short life cycles, high reproductive rates, and endurance and tolerance of handling, show good potential for vermicomposting.

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. So, better composting requires only certain species of earthworms which have some specialty. Diversity of earthworm species varies with different types of soils and environment and hence choosing a local or native species of earthworm for the local soil and for vermin-composting is an important step. It is generally accepted that epigeic species have a greater potential as waste decomposers than anecics and endogeics.

The commonly used epigeic species are temperate Red Wiggler or *Eisenia fetida*, tropical African Night Crawler or *Eudrilus euginae* and tropical Indian blue or *Perionyx excavatus*. These are used all over the world for vermicomposting. Among the species *Eisenia fetida* and *Eudrilus euginae* are exotic and *Perionyx excavatus* is endemic. Other species that are sparingly used for vermicomposting are *Lumbricus rubellus,Dendrobaena veneta, Dichogaster curgensis, Eisenia hortensis, Drawida nepalensis, polypheretima elongate and Lampito mauritii.*

Conclusions and Remarks

The history of the Indian chemical fertilizer Industry dates back to 1906 when the first fertilizer factory opened at Ranipet (Tamil Nadu). Since then, there have been major developments in chemical fertilizer sector. The 'Green revolution' of the 1950s-60s came as a 'mixed blessing and curse combination' for us. It boosted food productivity, but decreased its 'nutritional quality' and also the 'soil fertility' and depleted ground water level over the years. Chemically grown foods have adversely affected human health.

On the other hand, earthworms have over 600 million years of experience as waste and soil managers. Worm Castings are a perfect organic and natural fertilizer with naturally balanced, high levels of minerals and nutrients for plants. Through their castings earthworms convert a product of 'negative value' *i.e.* 'waste' into a product of 'highly positive, economic, environmental and sustainable values' *i.e.* 'highly nutritive organic fertilizer'.

Worm castings (a.k.a. worm manure, vermicompost, or worm excreta) are rich in plant nutrients, trace minerals and growth enhancers, and incorporating castings into the soil significantly increases microbial life in the root zone. Worm castings are extremely beneficial in that they stimulate plant growth more than any other natural product. Vermicompost is proving to be highly nutritive 'organic fertilizer' and a 'miracle growth promoter' rich in NKP (nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, beneficial soil microbes and also contain 'plant growth hormones & enzymes'. Evidences are accumulating all over the world that the earthworms and their vermicompost can do the miracle. They can 'build up soil', 'restore soil fertility', 'maintain ground water level' 'sustain farm production' and also deliver 'safe food' for the human being.

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