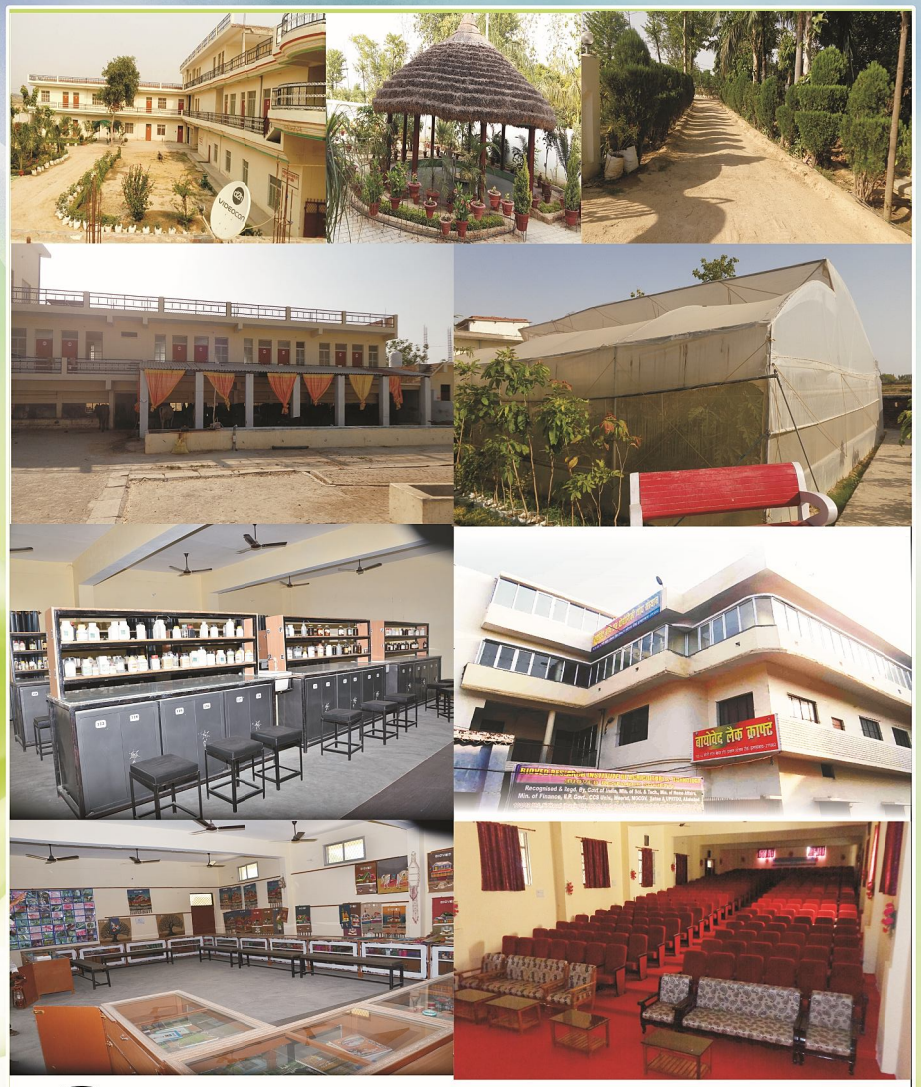

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TECHNOLOGIES FOR

DOUBLING FARMERS' INCOME

(Proceedings of 20th Indian Agricultural Scientists & Farmers' Congress on "Recent Need Based and Eco-FriendlyTechnologies for Doubling Farmers' Income" during 17-18 February 2018, Allahabad)

Co- sponsorers
ICAR, CSIR, NABARD

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CONTENTS

Vermicomposting : New approach to waste management and sustainable agriculture

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Vermiresources are mainly annelids useful for man and his environment. Earthworms are important Vermiresources having simple, cylindrical, coelomate and segmented body characterized by presence of setae. They form a major component of the soil biota and together with a large number of other organisms constitute the soil community. They are known for inhabiting the earth's soil since the Precambrian period dating back about the 600 million years, bearing a silent witness to plant and animal evolution through the several landmarks and debacles of the evolutionary paradox. The basic design of earthworms has not changed much over millions of years and also much variation did not occur between the species.

Earthworms have dynamic potentials and they perform wonderful job to maintain nutrient balance in the soil by recycling of organic waste. They are also used as protein rich source of animal feed because they have 70-80% protein on a dry mass basis. The earthworms are highly resistant to many pesticides and heavy metals. They have capacity to accumulate pesticides and heavy metals in their tissues and or convert them into non-toxic materials. Since earthworms have the ability to take up in their tissues a number of unwanted chemicals, they may be used as indicators of pollution. Earthworms also play a significant role in management and reclamation of degraded pedoecosystem. The introduction of earthworms in degraded land enriches the exhausted soil with nutrients.

The earthworms are unique creatures of animal kingdom. They belong to phylum Annelida and order Oligochaeta. They are bisexual or hermaphrodite and normally live in burrows or tunnels in the soil and eat soil mixed with dead and decaying organic matter, hence they are known as earthworms. The earthworms have worm-like elongated, cylindrical and soft body with metameric segmentation, i.e. whole body is uniformly divided in similar looking, ring like segments. They do not possess true appendages and specialized sense organs. They bear chitionous hook like setae that help in locomotion.

Earthworms are terrestrial worms well adapted for burrowing life. They depend on soil for all of their activities hence they are called geobionts. In order to protect themselves from enemies and desiccation most the species prefer to live in burrows and come out during night in search of food (night crawlers). Earthworms are also known as rain worms, as they are seen in large numbers during rains, manure worms, as some varieties flourish well in manures and compost heaps, angel worms as they suddenly appear like angels after some days of rains, or fish worms as they are largely used as fish bait and fish food. Earthworms play a significant eco-functional role in soil ecosystem by affecting physical, chemical and biological properties of the soil. They are the major constituent of the community of biodegrading organisms. They enhance circulation of air and water in the soil, they turn the soil up and down and in association with microorganisms, they convert organic waste matter into bio-compost. They also release plant growth promoting factors. Thus it is believed that they help to maintain soil fertility. A large number of earthworms are indicative of fertile status of the soil.

Earthworms, on the basis of habits, habitat, colouration, body size, life cycle, fecundity, are classified into three groups or categories:

Epigeic worms: Epigeic earthworms live on the surface of the soil in leaf litter. These species tend not to make burrows but live in and feed on the leaf litter. Epigeic earthworms are also often bright red or reddy-brown, but they are not stripy. They have the ability to survive in adverse conditions, short life cycle, moderate to high rate of cocoon production, capacity to build up high population density and are highly suitable for recycling of organic waste (vermicomposting).

Endogeic: Endogeic earthworms live in and feed on the soil. They make horizontal burrows through the soil

to move around and to feed and they will reuse these burrows to a certain extent. Endogeic earthworms are often pale colours, grey, pale pink, green or blue. Some can burrow very deeply in the soil.

Anecique or anecic : Anecic earthworms make permanent vertical burrows in soil. They feed on leaves on the soil surface that they drag into their burrows. They also cast on the surface, and these casts can quite often be seen in grasslands. They also make middens (piles of casts) around the entrance to their burrows. They are darkly coloured at the head end (red or brown) and have paler tails.

The ability of earthworms in decomposition of waste materials and enhancing soil fertility has been recognized since thousands of years but their contribution in modern agriculture has been neglected due to extensive use of agricultural chemicals as fertilizers. Due to some short-comings and ill effects of modern technologies and unsustainable developments, particularly in the field of agriculture, the importance of eco-friendly technologies and sustainable development is now stressed upon. The potential of earthworms in soil processing due to their burrowing nature and composting of organic matter has been realized and simple appropriate vermiculture biotechnology has been developed which may solve the problems of waste processing and management to a large extent. Additionally it results in production of useful end product that helps in sustainable agriculture.

Legislation for protection of environment, decreasing landfill space and increasing public awareness have drawn our attention towards alternative strategies for recovery of rich pool of nutrients from such wastes. Composting and vermicomposting are two of the best known processes for stabilization of solid organic wastes. Although microorganisms are mainly responsible for biochemical degradation of organic matter in both the processes but earthworms play a vital role along with microbes during vermicomposting. The worms actually enhance microbial activity and diversity and lead to rapid degradation of waste and recovery of nutrients.

Many organic byproducts of agricultural production and processing industries are currently seen as waste and thus become potential environmental hazards. Likewise leaves, lawn clippings, paper, restaurant food waste have become a problem. A portion of this waste is currently reused, recycled or reprocessed, however a majority of it is disposed off in Landfills (anaerobic composting) which is a national concern due to many factors including cost and environmental issues? Safe and non-hazardous management of waste is a problem of the modern civilized society. The diversity and quantity of solid waste have shown tremendous increase with rapidly increasing human population, urbanization and high rate of industrialization. Due to declining interest in organic composts and non judicious use of chemical, fertilizers, biodegradable organic wastes have become extra source of pollution. Usually in-adequate and in-appropriate methods of waste management, such as dumping, land-filling, burning etc. are adopted which are not safe to the environment and for human health.

During recent years, applied use of earthworms in the breakdown of a wide range of organic residues, including sewage sludge, animal wastes, crop residues, and industrial refuse to produce vermicompost, has been recommended. A special class of high performance species of earthworms (epigeics) have been identified which can be employed for large scale bioconversion of organic waste into vermicompost. In fact the earthworms work in collaboration with aerobic bacteria. This type of waste degradation and composting system is proving to be economically and environmentally suitable technology over the conventional microbial degradation and composting technology, as it is rapid and nearly odorless process, reducing composting time by more than half, significantly reducing the environmental hazards, improving quality of the compost and the end product is both disinfected and detoxified. Bio-conversion of waste by culture of epigeic earthworms is known as vermicomposting. But in fact it involves the bio-oxidation and stabilization of organic matter through the joint action of earthworms and microorganisms, particularly aerobic bacteria as they have close relationship with each other. Vermicomposting is non-thermophilic stage of waste processing.

Vermicompost is mature peat-like material with a high porosity, aeration, water holding capacity and microbial activity which are stabilized by interaction between earthworms and microorganism in a non-thermophilic process. Vermicompost has large particulate surface area that provides many micro sites for the strong retention of nutrients. Vermicompost is rich in microbial populations and diversity particularly fungi, bacteria and actinomycetes. Application of vermicompost increases the total microbial population of nitrogen-fixing bacteria and actino-

mycetes in the soil. Due to increasing microbial activity in the soil, degradation of organic waste continues in the soil also and it also improves the availability of phosphorous and nitrogen for the growing plants.

In India the vermicomposting program was launched during 1990 and Prof. Radha D. Kale (Bangalore), Prof. B.K. Senapati (Sambalpur), Dr. Uday Bhawalkar (Pune), Bhiday were among the pioneer workers. Commendable works on vermicomposting have also been done at Bhawalkar Earthworms Research Institute (BERI), Pune, Tata Energy Research Institute (TERI), Delhi, National Environmental Engineering Research Institute (NEERI), Nagpur, Institute of Natural Organic Agriculture (INORA), Pune.

Vermicomposting is simple, easy, efficient, organism based, user friendly, economically viable technology of solid waste management that can help in sustainable development for environmental conservation, agricultural development as well as socio-economic development. The practice is slowly getting popularity. Several attempts have been made to study bio-conversion of different wastes including animal wastes, crop residues, industrial refuge and Municipal Solid Waste (MSW), using earthworms. However, in most of the vermicomposting units cattle dung mixed with crop residues is used and enough attention has not been made to incorporate other type of wastes.

The solid waste from agriculture, food and food processing industry, paper and card board industry, human habitation, animal excreta etc usually contain a wealth of components that could be the source of nutrients to vegetative plants. But most of them cannot be directly applied to the soil because they may cause harmful effects on the plants and they may require longer time for decay due to their complex nature and depleted microbial diversity in the soil due to excessive and non-judicious use of agricultural chemicals. Thus it has been recommended that waste biomass should first be converted into bio-compost through self-composting, bacterial inoculation, biogas processing or vermicomposting. Some of the scientists focused their attention on treatment of sewage sludge through vermicomposting because introduction of epigeic earthworms in aerobically held sewage sludge is supposed to enhance aeration to make it suitable for the action of aerobic (composting) bacteria. Mixing of sludge with other coarse waste material helps to improve bulk density and C/N ratio of the medium and make it favourable for vermicomposting.

Exploitation of earthworms for biodegradation of organic wastes is a recent development in biological sciences, although the first scientific approach to study earthworms was made by great biologist Darwin in19th century in his classical publication, **"The formation of vegetables mould through the action of worms, with observation on their habits".** He described the role of earthworms in these words: **"The plough is one of the most ancient and most valuable of man's inventions, but long before he existed, the land was in fact regularly ploughed and still continues to be thus ploughed by earthworms".**

The earthworms feed on partially decomposed organic matter and their digestive tract acts as grinding mill reducing the particle size of the food, then acting as a bioreactor in which waste products are processed into organic manure in the form of worm cast with the help of microorganisms and digestive enzymes. It is estimated that the earthworms can consume waste stuff equivalent to 4-5 times of their own body weight per day and they produce cast equivalent to about 50 percent of the waste they consume. The cast is passed out of their bodies in the form of granular aggregates. Earthworms consume various organic wastes and reduce their volume by 40-60 percent. Thus 1 kg of earthworms could decompose approximately 4-5 kg of organic matter in 24 hours. The nature of food and its availability and other physical parameters like temperature, light, moisture content and biological parameters like the density pressure, environmental conditioning created by their own activity influence their growth and fecundity.

Vermicompost can be produced from almost all kinds of organic waste with suitable pre processing and controlled processing conditions. In India the Vermi-technology process has been evaluated for treatment of agro, sugar, food processing and other wastes. Recycling of wastes through vermitechnology reduces the problems of non-utilization of agro waste. Vermicompost has gained importance because of its higher economic value compared with compost derived from traditional methods. Nutrients present in vermicompost are readily available for plant growth and vermicompost has a higher concentration of available nutrients than the wastes from which it is formed.

Earthworms not only play an essential role in nutrient cycling and soil turnover, they exert a slow but substantial influence on the landscape itself. Economically they are important participants in many large-scale composting programs and in multi-million-dollar fishing bait industry. As Charles Darwin (1881) put in "**Worms have played a more important part in the history of the world than most persons would at first suppose".**

Vermicomposting practice provides an extra source of income mainly to the farmers and cattle breeders. Unemployed persons can adopt it as means of self-employment. The practice strengthens the concept of environmental conservation through reduction in pollution caused by agricultural chemicals and mismanagement of waste products. Vermicomposting provides a win-a-win solution of all the problems mentioned above. Vermicomposting of organic wastes not only solves the problem of waste disposal in an eco-friendly way but also provide nutrient rich vermicompost to boost our agro-ecosystem.

On account of increasing human population, all over the world, especially in under-developed and developing countries, importance of the efforts to increase crop production had always been there and will always remain. In order to make human living more smooth and comfortable, modern tools of agriculture (mechanization and chemical fertilizers and pesticides) have been discovered and used to increase crop production. This was a successful and big event popularly known as **Green Revolution**.

Excessive, non-judicious and long term use of chemical agents, particularly fertilizers and pesticides have resulted in several problems including environmental pollution, health hazards, pest outbreak, pest resurgence, emergence of new pests, pesticide resistance etc. Due to toxic residues of chemical fertilizers and pesticides and lack organic matter in the soil, biodiversity and populations of beneficial flora and fauna of soil including earthworms are declining. The livelihood of the soil is at risk; soil is becoming dead and non-productive. It is getting deprived of micro and mega-nutrients and the situation of soil fertility is deteriorating to such an extent that nothing can be produced without addition of chemical fertilizers and increasing amounts of fertilizers are not resulting in increasing crop production to the desirable level. The input demands of soil are increasing and nobody knows where it would end.

The natural organic resources, instead of being added to the soil, are being destroyed and are being considered as wastes. They have become additional source of atmospheric pollution through their mis-management, such as burning, dumping, piling up, land filling etc. The variety and quantum of biodegradable and non - biodegradable waste materials are increasing. Safe disposal and management of waste particularly organic waste are global problems, which are much more serious in developing countries like India. A major portion of the waste is burnt to quickly get rid of it. The other waste remains are collected and dumped at empty plots or barren land within or at outskirts of the city as land filling or heaping for self decomposition. These practices create soil, air and water pollution which are the cause of environmental, climatic and health problems. During disposal, collection and handling of the garbage, other than organic wastes also get mixed up and recycling becomes much more difficult. In fact no serious thought is given for recycling and its benefits have largely been neglected.

Now there is a growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection. On the one hand tropical soils are deficient in necessary plant nutrients and on the other hand large quantities of such nutrients included in domestic wastes and agricultural by-products are wasted. It is estimated that in cities and rural areas of India nearly 700 million tons organic waste is generated annually. Such large quantities of organic wastes generated also pose a problem for safe disposal. Most of these organic residues are dumped on waste-land, used as land fillings or burned. The current methods of disposal and management of organic waste lead to heavy pollution of the environment. Along with other sources of environmental pollution they contribute in enhancing the problems of greenhouse effect, global warming, ozone layer depletion, deterioration of product quality, human health hazards etc.

Selected species of earthworms are used for the stabilization of organic wastes wherein the stimulating effect of earthworms on these will bring about mechanical and biochemical changes. When monocultures of earthworms have to be maintained for treatment of wastes, the intrinsic and extrinsic factors play an important role in the study state growth and establishment of populations. The population growth of *Eisenia foetida* (Savigny) and *Eudrilus*

eugeniae (Kinberg) was found to depend on the quality and quantity of the available food, culture media, temperature and moisture levels. The earthworm species that are more commonly chosen due to their high performance are *Eudrilus eugeniae*, *Eisenia foetida, Perionyx excavatus, Lumbricus rubellus, Drawida willsi, Lampito mauritii* and *Octochaetona serrata.*

In India manurial resources and organic waste are abundantly available for their bio-conversion into vermicompost with the employment of one or another species of earthworms. Total annual waste biomass production in the country is about 2500 million tons, out of this; animal dung alone constitutes about 60%. Like human beings, earthworms also need a complete and balanced food containing all the necessary macro and micro nutrients that can easily be digested and assimilated. The feed stuff also acts as medium (habitat) for their livening and activities. Further, the medium should have proper C/N ratio, enough moisture, suitable pH and aeration as the worms do need oxygen for cutaneous respiration. For epigeic earthworms, suitable for vermicomposting, cattle dung is the ideal culture medium, the other waste media may contain more nitrogen than carbon or *vice versa*, may be too much acidic or too much alkaline, may have too low or too high water content may have too high or too low bulk density, the last two factors affect proper aeration. Thus such waste stuff is to be amended with other waste stuff (s) so as to balance these conditions. The earthworms are not able to engulf solid food particles as they do not have jaws and teeth. The aerobic bacteria first act upon the food and start its digestion and liquefaction. The worms consume this semi-solid, partially digested matter along with bacteria. Further, fragmentation and decomposition of ingested stuff takes place in the gut of earthworms involving churning in the gizzard and the activities of gut enzymes and bacteria. The alimentary canal, of worms, acts as bioreactor, where the bacteria grow and multiply rapidly. The total bacterial counts of the gut content and worm excreta (vermicompost) are therefore much higher than in the initial bedding material. Earthworms help in the multiplication and distribution of microbes. Together with earthworms, the microbes mineralize, humify organic matter and facilitate chelation of some metal ions. It can be concluded that Vermicompost can be a better option than synthetic fertilizers in increasing the fertility of soil and in turn increasing the productivity and also it would reduce the pollution load of our environment.