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Review Article

Role of Earthworms in promoting Sustainable Agriculture in India

Shruti Gupta, Tanuja Kushwah and Shweta Yadav*

Department of Zoology, School of Biological Sciences
Dr HS Gour Central University
Sagar (MP)-470003, India
**Corresponding author*

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A B S T R A C T

Over 50 years since its independence, India has made immense progress towards food security. Indian population has tripled, but food-grain production more than quadrupled: there has thus been substantial increase in available food-grain per capita. This was because of high yielding varieties, chemical fertilizers, and improvement of irrigation facilities. The country now has a buffer stock of about 35 million of food grains. But according to Dr. Kalam's prediction India may have to import about 14 million tones of food grains by 2020 and then imports will grow at the rate of 2 per cent every (India 2020: A Vision for the New Millennium). This is because our productions of food grains have reached to a saturation stage or stability there is a need for making changes in our agricultural practices. One of these, use of vermicompost in place of chemical fertilizer. The use of chemical fertilizers have made our soil non productive while efficiency of fertilizers themselves have also gone down. Intensive agriculture employing high yielding varieties in a monoculture set up needs large quantities of same nutrients year after year has exhausted the soils of micronutrients while, micronutrients are on the verge of depletion. Vast amount of nutrient are removed by these crops in an intense crop rotation system. The removal of nutrients at this pace is degrading soil texture and structure. The green revolution in India has led to indiscriminate use of fertilizers to obtain two three crop yields per annum. In the course of time, the tropical soils which are prone to depletion in carbon level and other nutrients are turning unproductive due lack of proper organic amendments. Now, is costlier to maintain plants in hot climates because of high temperature and water stress. A tenfold increase in use of fertilizers, pesticides and machinery compared to a mere two fold increase in agricultural production is economically not viable in the country with marginal and medium land holders. It is known that for every tone of food grains produced, 50 kg N, 30 kg P and 90 kg K are utilized as chemical fertilizers

Introduction

Historical Background of Agriculture in India

India over several millenniums has been the treasure land of biological wealth, intellectual knowledge and spiritual wisdom. It had also been the cradle of many ancient human civilizations like the world famous Indus valley, Ganges delta,

Cauvery delta civilization etc. During both pre and post Vedic periods, arts, science and technology had flourished well in various fields. Ancient mathematicians India invented the 'Zero' and made remarkable contributions to the field of 'Algebra'. An ancient astronomer named Aryabhatta had discovered the earth's rotation and also the solar and lunar eclipses. Five planets had been known to the Vedic Indians even before the telescopes were invented. Ancient physicians had established two excellent medicinal systems viz., 'Sidha' and 'Ayurveda' which are now recognized as 'healthy friendly' systems.

Similarly the biological wealth of India could be evidenced in the report of Kothari (2001). India is classified among the 12 mega diversity centers of the world in relation to crops. As many as 167 species of crops, 320 species of wild crop relatives and several species of domesticated animals have been identified. The genetic diversity within these species is outstanding. Some examples are rice (50,000 varieties), sorghum (5,000 varieties), mango (1000 varieties), pepper (500 varieties), cattle (27 breeds), sheep (40 breeds), poultry (18 breeds) and buffalo(8 breeds).This amazing diversity is not a stake of nature, but a result of careful selection and even cross breeding, over centuries, by India's farmers and pastoralists. Hence, Indian agriculture, to such an extent, is much traditional and dates back to about 10,000 years. India with its traditional crop varieties and crop production techniques was able to feed its population and was exporting some selected produces to other continents. All the Indian villages were self sufficient, self sustained and self-reliant units. In fact, urban centers were dependent upon the villages rather than vice-versa.

When India attained independence, it faced a severe shortage of food supply during 1950's and 60's due to various reasons. To overcome this problem, India entered in the era of Green Revolution. By this, self sufficiency in food production was somehow achieved with the introduction of so called high yielding varieties, inorganic fertilizers, pesticides, modern implements etc. These were imported from western countries in the name of 'technological packages' without taking care of their adaptability to Indian conditions and the possible consequences. The development of modern agriculture production was achieved by creating large scale specialized farm production units, increased mechanization and use of chemical inputs.

Feasibility of Organic Farming in India

Organic farming has twin objectives of system sustainability and environmental sensitivity. In order to achieve these two objectives, it has developed some rules and standards which must be strictly adhere to. In India, with ever increasing population, there is increasing demand for food and with meager availability of organic resources, total organic farming is not possible. However, some specific areas can be diverted to organic farming for export of high quality organic products, more specifically high value horticultural crops. Thus, as a whole under Indian conditions, only partial switching to organic farming is possible, presently.

In Indian agriculture, use of chemical fertilizers cannot be totally eliminated; rather it can be reduced, or minimized. It has been proved by various experiments that by conjoint application of inorganic fertilizers along with various organic sources it is possible to sustain higher crop productivity, improved soil quality and

soil productivity besides meeting N, P and K requirement. These organic sources also help in alleviating the increasing incidence of deficiencies of secondary micronutrients. At present the commercial mineral fertilizers are the main sources of plant nutrients. Therefore, these organic resources should be used in integration with chemical fertilizers to narrow down the gap between addition and removal of nutrients by crop as well as sustain the quality of soil and achieve higher crop production. Nationwide adoption of organic farming is not possible due to unavailability of organic resources, reduction in productivity etc. which will leave many people hungry. In this context, renowned Agricultural Scientist and thinker Dr M.S. Swaminathan (2003) said that "a hungry man is an angry man" and "if the hungry man happens to be a young man, then we have a potential terrorist among us".

Thus, in India, adoption of organic farming is possible only for crops having high export potential in international markets. On the other hand, full adoption of Integrated Green Revolution farming, another option to organic farming is possible to a large extent, in areas where, the basic features of green revolution such as intensive use of external inputs, increased irrigation, use of high yielding and hybrid varieties, mechanizations, limited damage to the environment and human health. For this purpose some organic techniques are developed and combined with input technology to create integrated systems such as "Integrated Nutrient Management" (INM), "Integrated Pest Management" (IPM) and biological control methods which reduce the need for chemicals.

Hence, for the developing countries like India, other alternatives *viz.* traditional methods have special advantages over modern agricultural techniques. Also the capital and skill requirements in the use of traditional technologies are generally low and their adoption often requires very little restructure of the traditional societies. These traditional technologies are nothing but indigenous knowledge. By adopting such indigenous knowledge our ancestors did not face any problem of large pest outbreak or economic crisis unlike the today's fa

Nowadays Natural Farming, Organic Farming, Eco-Agriculture, Permaculture, Bio-dynamic Agriculture, *Rishi Kheti*, *Sadhu Kheti* and so generates lot of curiosity among general public. Although, all these words differ slightly in precise meaning and emphasis, the underlying conceptual idea is same. Their descriptions and methodologies are derived from a close study of nature. They all agree in principle of least interference in natural systems to raise healthy plants and animals. They all agree in limiting and in some cases eliminating use of artificial chemicals and heavy machinery in agriculture. They all aim at quality and nutritious nature of the farm produce.

Role of Earthworms in maintaining Sustainable Agriculture

In underdeveloped countries, green revolution has resulted in boosting the production due to intensive agriculture. Although it has resulted in good harvests and productivity by reaping three crops in a year with good irrigation facilities, there was no thought about its adverse impact in the long run on the soil conditions and the environment, particularly during the last four decades. With the extensive use of chemical fertilizer and improper irrigation, productivity of the soil is getting reduced

considerably. The permanent and cheapest solution to overcome the dangerous effects of modernized agriculture is to develop a farming system which is economically productive and long-lasting in sustainable farming or natural farming by simple and inexpensive practices like vermibiotechnology. Thus the old agricultural systems *viz.,* biological, organic, ecological, regenerative, natural, biodynamic and low input agriculture are reconsidered for their sustainability.

Vermitechnology: A global movement

The movement was started in the middle of 20^{th} century and the first serious experiment for management of municipal/industrial organic wastes was established in Holland in 1970 and subsequently in England and Canada. Later vermiculture were followed in USA, Italy, Philippines, Thailand, China, Korea, Japan, Brazil, France, Australia and Israel. However, the farmers all over the world have been using worms for composting their farm wastes and improving farm soil fertility since long time.

Promotion of Vermitechnology for Sustainable Agriculture

Sustainable agriculture is a process of learning new and innovative methods developed by both farmers and the farm scientists. And, is also learning from the traditional knowledge, practices of the farmers and implementing what were good in them and also relevant in present times. Vermiculture was practiced by traditional and ancient farmers with enormous benefits accruing for them and their farmlands. Therefore, there, is a need to revive this 'traditional concept' through modern scientific knowledge '*A Vermiculture Revolution'*. Sir Charles Darwin called the earthworms as 'farmer's friends'. There is great wisdom in this statement of the great visionary scientist who advocated to use the earthworms, the 'nature's gift' in farm production. It is necessary to adopt and implement food & agriculture production system which must ensure: maintenance of soil microbiology and fertility by greater use of biofertilizers; high productivity and stability of yield over the years; productivity with 'minimum' or 'no' tilling; 'low' use of agro-chemicals and integration with biofertilizers and biopesticides; productivity with minimum use of water and even sustaining dryness or heavy rainfall; preservation of crop diversity (biotopes);preservation of soil, water and air quality in the farm ecosystem; preservation of benevolent organisms (predators) flora & fauna in the farm ecosystem; Preservation of groundwater table; preservation of good health for all; reduction of water and energy use.

Sustained vermiculture practices and use of vermicompost in farm soil over the years would meet several of the above requirements for a truly sustainable agriculture. Vermicompost is rich in microbial diversity and plant available nutrients; improve moisture holding capacity of soils, thus reducing water for irrigation; improve physical, biological and chemical properties of soil; increase soil porosity & softness, thus requiring minimum tillage.

Vermi-biotechnology is an eco-friendly, socially sound and economically viable innovative type of technology to manage the organic waste resource on low capital input basis does not call for expensive laboratories or sophisticated industrial instruments. It can provide employment to

millions of youth; can eliminate the dependence on chemicals, convert wastes into fertilizers, can bring waste-land under cultivation, can feed hungry citizens and can make a country green and prosperous in a span of just a few years.

It is basically composting with earthworms (*Eisenia fetida, Eudrilus eugeniae, Perionyx excavatus)* in native all organic matters eventually decomposes. It can be virtually anywhere either indoor or outdoor conditions. Organic wastes used for composting are animal dung (cattle dung, sheep dung, horse dung, goat and poultry droppings), agricultural waste (after harvesting and threshing of the produce), forestry wastes (wood-sawing, peels sawdust and pulp), city leaf litter (mango, guava, oranges etc., from residential areas) and paper and cotton clothes (if these are not being recycled for useful products, can be recycled with this technology) etc.The earthworms perform all processing naturally and resulting product provides stable organic matter. It increases water-holding capacity and improves soil quality, pH, soil biological activities and the soil productivity in subsequent years.

6.0 Vermitechnology and Sustainable Food Production

Earthworms have over 600 million years of experience in waste & land management, soil improvement & farm production. Sir Charles Darwin called them as the '*unheralded soldiers of mankind and farmer's* friend working day and night under the soil'. Vermiculture biotechnology promises to provide cheaper solutions for:

- Management of municipal & industrial solid wastes (organics) by biodegradation & stabilization and converting them into nutritive organic fertilizer (vermicompost) management was emphasized by Greek Philosopher Aristotle who called as 'intestine of earth' which meant that they can digest wide variety of materials from earth.
- Restoring & improving soil fertility and boosting food productivity by worm activity and use of vermicompost (miracle growth promoter) without recourse to the destructive agro-chemicals.

Nations of world today are seeking the most cost-effective, economically viable, environmentally sustainable & socially acceptable technology that can convert all 'organic waste' into a valuable 'resource' to be used back into the human society. Earthworms have potential of generating NPK equal to 10 million tonnes annually in India (and other nations too) as huge amount of organic waste is generated every year and 1,000 tonnes of organic wastes can be degraded to 300 tonnes of nutritive vermicompost rich in NPK and all essential micronutrients by about few million worms whose population almost double every year. The organic fraction of the MSW (about 70-80%) containing plenty of nitrogen (N), potash (K) and phosphorus (P) is a good source of macro and micronutrients for the soil. Vermicomposting of all waste organics especially the 'food & garden waste' of society and using the nutritive end-product to grow 'food' again will establish the concept of 'circular metabolism' for a sustainable society.

Vermitechnology in India

The use of *Perionyx excavatus* was the beginning of pioneering attempt in India to employ earthworms for the degradation of solid waste. Later *Eudrilus eugeniae*

was brought to the laboratory in University of Agricultural Sciences Bangalore to test the possibility of their establishment in this subcontinent which has similar climatic conditions as that of its place of origin. Since, 1982 *Eudrilus eugeniae* has been promoted for waste degradation. When compared to *Perionyx excavatus,* this species has surpassed both in feeding and reproductive rate. In the beginning, it was thought that the response may be short lived, as many organisms show a tendency to perform extremely well in a new environment till they get established. Such a change in their efficiency has not been observed in the past many years. A series of experiments has shown that it is an ideal species to work on agricultural and agro-based industry waste. Their sensitivity to density pressure and meandering nature demand larger area of space for their establishment. At the same time *Eisenia fetida* also entered in Indian laboratory from Germany and is preferred species for composting activity in the urban areas (urban waste).

The *University of Agricultural Sciences, Bangalore*, India initiated vermiculture in India and they propagated the knowledge of vermiculture to farming community. The university released the technology to the farmers in the year 1984. At initial stage, several controversies were developed about the composting and selection of species of earthworms. Most of the researches were of opinion that indigenous species of earthworms should be used for composting instead of exotic species. The group that opposed the use of exotic species in this country lacked the knowledge of their feeding habits, habitat preference, reproductive potential and ability to survive in captivity to accept them for vermicomposting. But a detailed and in-depth study of the biology of 03 out of 14 species of earthworms collected during the survey of middle Gangetic plains of India helped us to put forward our views that a very few species of earthworms can be used for composting purpose and a few more as co-inhabitants to hasten the process of decomposting along with other soil organisms (Verma et al., 2010). In India, which was under colonization for several centuries, exotic species of plants and animals have been transported either intentionally or unintentionally. The northern part of the country has more exotic species of earthworms than the southern peninsula.

Agriculture Colleges under Jawaharlal Nehru Krishi Vishvavidayalaya, Jabalpur, Kasturbagram and *Indore* also propagated the vermiculture technology to farming community in the state of Madhya Pradesh. There are many other organizations which have been active in popularizing vermicompost in many parts of the country.

Green Cross Society of Mumbai, a non-profit organization has set up several projects to convert organics into vermicompost. A smaller-scale unit with a capacity of 4 tons of slaughter house waste per day, and a large unit with capacity of 20 tons of vegetable waste per day, has been set up in Bombay, in collaboration with the Bombay Municipal Corporation.

Indian Aluminum Co. Ltd., Belgaum, Karnataka has initiated processing of garbage and sewage from 500 homes. Compostable garbage is processed in seven concrete vermicomposting bins (one for each day of the week). Sewage is fed to a 200 square meter "vermifilter" a bio-filter with a 30 cubic meter deep. The vemifilter can process up to 100 cubic meters of sewage per day, and the purified water is used to irrigate gardens.

This low-labor system needs little operation and maintenance.

M.R. Morarka – GDC Rural Research Foundation, Jaipur is popularizing vermicomposting in Rajasthan. They have conducted around 300 demonstrations on vermicompost in about 150 villages on various crops like bajra, wheat, barley, gram, moth bean etc.

Vermiculture Research Station, Aligarh is constantly striving to work in western UP with farmers and other groups to develop profitable vermicomposting project or business. They worked with farmers to develop practical solutions for organic resource management with a view to finding the right balance of materials and methods to meet the goals. Vermiculture is being practiced and propagated on large scale in India too as a part of the ' Agriculture Development Program' (to convert all the agriculture wastes into compost). Several organizations *viz.* government, private, NGOs etc. have come forward to educate the farmers in the use of vermicast or *in situ* Vermiculture. In this context, the Vermiculture Research Station, Aligarh (UP) India, standardized the procedure for the production of vermicompost and transferred the technology to farmers in different villages of Aligarh and Hathras districts through, series of educational training programmes that in turn have successfully transferred the vermitechnology to farmers at grassroots level. Vermiculture Research Station, Aligarh, harbors a reasonable diversity of earthworm species *viz.*, *Eisenia fetida, Perionyx excavatus* and *Eudrilus eugeniae.*

Some success stories of Indian Vermi-entrepreneurs

In India, green revolution has resulted in boosting the production due to intensive agriculture. Although it has resulted good harvests and productivity by reaping three crops in a year with good irrigation facilities, there was no thought about its adverse impact in the long run on the soil conditions and the environment, particularly during the last four decades. With the extensive use of chemical fertilizers and improper irrigation, productivity of the soil is getting reduced considerably.

Vermicomposting activity is being implemented successfully in villages of Aligarh and Hathras district of Uttar Pradesh in India with the assistance of the Department of Biotechnology, Government of India. A regular farmers' meet was organized for creation of awareness on the production and application of vermiculture as well as establishment of entrepreneurship among the rural people. The project was implemented with the technical assistance of Dharm Samaj P.G. College, Aligarh (UP) in five Panchayat blocks, namely, Lodha, Jawa, Khair, Tappal and Dhanipur of District Aligarh and Hassain, Mursan of District Hathras of Uttar Pradesh. In Rajpur village of Tappal Block, a progressive farmer, Shri Asha Singh is producing the vermicompost in bulk and himself applying upto 50-60 mt per month in the fields of paddy and vegetable crops. More than hundred farmers of Aligarh district have applied vermicompost in their fields and are not only saving upto fifty per cent of chemical fertilizers but also got 10-15% enhanced yield. According to the farmers' self assessment through their farming, vermicompost is 4-5 times more effective than the conventional compost and this has developed competition among the farmers to produce more and more crop yield through vermicomposting (Biotech News Letter, 2003). A progressive farmer

of Khushal Gari village, Atrauli Block,Aligarh owns a nursery of horticulture plants and has earned an income of around US$ 2500 through production and sell of earthworms and vermicompost besides meeting his own nursery requirements. He also experimented the use of vermicompost in grafting of horticulture plants and observed a major change in accelerating the rooting of grafted plants**.**

Some of the enterprising graduate students have established their own vermiculture units, which enable them to meet their contingency requirements. Realizing the success of this programme, rural banks of district authority have come forward to finance and associate themselves to the rural community to work for the technology dissemination and to encourage more and more farmers to adopt vermicomposting. Establishment of hatcheries and making available suitable earthworm quantity are the key factors for awareness building and popularization of vermicomposting in rural areas.

Mass rearing and maintaining worm cultures and tapping of organic wastes for their maintenance has a good scope for developing it as a cottage industry in developing country like India to mitigate the problem of affecting crop diversity due to intensification and use of inorganic fertilizers and pesticides. The tapping of this resourceful technology is of utmost importance in the present day "as soil is the placenta of life" to meet the requirement of rural India. This approach would help in developing a biovillage cluster. The country has no dearth for organic wastes, congenial climatic conditions and required manpower.

Self help group approach is developing in a major way in vermicomposting in all the blocks of Aligarh district and village banking institutions are highly impressed with the micro-credit system established by the village community. Good linkages have been developed in the village cluster for marking the worms and compost produced through cooperative building and self help groups. Trained beneficiaries are being financed for the establishment of vermicompost units and vermiculture to propagate the activity in the village at large scale.

Developing women vermi-entrepreneurs

In order to develop women vermicompost projects. different village's farmers and respective "Gram Sabhas" of the villages namely, Devinagla, Alinagar, Balukhera, Jalupur Syore, Faridpur, Kheda Narainpur, Pankhani, Bhadasi, Gyanpur etc. of Aligarh district of Uttar Pradesh were surveyed. Pankhani (Dhanipur block), Bhadasi (Lodha block), Balukhera (Dhanipur block), gyanpur (Chandosi block) were selected for the purpose. As such some 15 women family of Pankhani, 17 women family of Balukhera, 03 women of Bhadasi and 4 women of Gyanpur (family members) from these villages agreed to take up the vemricompost projects in their own houses. The women units were provided 8 kgs earthworms for two beds, tools (one Hazara and one punja). Women farmers' of these villages are using vermicompost in their own rabi and kharif crops.

The painstaking efforts made in developing women vermin-entrepreneur units (Aligarh UP, India) during the study period have brought tangible results by way of: (i) setting-up a hatchery-cum-demonstration unit, comprising 60

vermibeds;(ii) providing 4000 kg vermiseeds to beneficiaries;(iii) organizing 13 training programmes on vermitechnology where some 600 women farmers participated; (iv) setting-up of 270 vermicompost units by women farmers in rural areas; (v) production and sale of 19 mt vermicompost through sale-purchase-counters by SHG of women farmers, fetching them an earning of Rs. 5 lakhs annually; (vi) development of two 'vermi-villages' for sustainable supply of earthworm seeds to new upcoming beneficiaries; (vii) organizing exhibition, bio-fairs, meetings by the project on vermitechnology, providing recent updates by experts, where some 4350 farmers and others participated; (viii) participation of project in the Govt. exhibitions, "krashak gosthi", meetings to educate, train and provide information on vermitechnology through interaction with farmers and exhibits, models etc; (ix) analysis of field soil where vermicompost has been used; (x) new initiatives on organic cultivation of vegetable and horticultural crops by SHG of women farmers, fetching them high prices.

Although the objectives of the vermi-project have been achieved far and wide, and participating women farmers of the study area (Aligarh) feel privileged and empowered with Vermitechnology at their hand, yet, there is still a necessity to continue these efforts in adjacent districts to run this programme in order to ensure participation of women in this new venture.

Analysis of soil constituents of farmers' fields

Vermicompost is being produced by the Vermiculture Research Station, Aligarh UP over the years. As one of the project objectives, we have made an attempt to analyze some 100 soil samples collected from women farmers' fields in which vermicompost was applied. The study has revealed that there is an increase in carbon percentage from 3.28 to 6.19 in these fields. Further, the pH of the same fields was decreased from 9.88 to 8.69 and increase in nitrogen (196 mg/100g to 252 mg/100g), potash (13.2 to 21.6 mg/100g) and phosphorous (89.4 mg/100g to 219.3 mg/100g) was observed. This indicated considerable improvement in soil constituents with the application of vermicompost.

Honoring farmers for their exemplary works

Six farmers were honored for their exemplary works in the area of vermitechnology and medicinal plants cultivation at 'Bio-Fair-2008' at Vermiculture Research Station, D.S. College, Aligarh, UP, India.

1. *Shri Asha Singh*, a progressive farmer from village Rajpur, khair, Aligarh UP has earlier been recipient of first prize from U.P. government in 1997 for sugar cane production. Shri Singh took exemplary interest in vermicomposting since, 2002 and has set up over 50 beds, thus far, producing over 600 Quintal vermicompost per month. He has marketed the produce @ Rs. 250 per Quintal earning Rs. 7500.00 besides using the vermicompost in his own crops. Shri Singh also multiplied the earthworms and sold over 60 kg @ Rs. 100/- per kg. Thus he has been successful in generating self employment through the encouragement, support and technology provided by Vermiculture Research Station, D.S. College, Aligarh and has encouraged fellow farmers.

2.Shri Ikram Ali, an ambitious farmer from Hassain Vikas Khand, Hathras, Uttar Pradesh took-up organic cultivation of medicinal plant Ashwagandha, applying vermicompost during 2007. He has produced 55 kg roots and sold these @ Rs. 50/- per kg, earning Rs. 2750/-. Shri Ali observed that there has been no effect of frost on the crop produced through vermicomposting whereas other crops of mustard & potato cultivated with application of chemical fertilizers were severely affected by frost. Shri Ikram Ali has been a source of inspiration to other farmers who are now initiating organic cultivation of medicinal crops.

3.*Smt. Kamlesh Devi* has been a very hard working progressive farmer. She received 38 kg earthworms from Vermiculture Research Station, Aligarh UP during 2007 and produced 33 Quintal vermicompost/month. She is selling 8 Quintal vermicompost monthly @ Rs. 200/- per Quintal and rest 25 Quintal using for her potato crop. Her efforts have yielded good results and she has become a role model for other women of the village.

4. *Smt. Shkuntla Devi*, with great enthusiasm from Dhanipur village, district Aligarh UP received 2-days training in vermitechnology at Vermiculture Research Station, Aligarh during 2007. In the first phase she prepared 2 beds and has been able to obtain 4 Quintal vermicompost. She encouraged 37 fellow women of village Chhitupur who have now taken-up production of vermicompost at mass scale.

5. *Smt. Rajni Devi*, woman from BPL group has been working since 2007; she had been given 132 kg earthworms through Vermiculture Research Station, Aligarh. She prepared 33 beds, giving a production of 152.50 Quintal vermicompost/month and selling @ Rs. 200/- per Quintal. Fifty percent of their production she used in her own crops of Potato & Wheat. Smt. Rajni Devi has become very popular and encouraged other women of the village to start producing vermicompost at their door-steps in villages.

6. *Shri Dhyan Pal Singh & Shri Nathi* Singh are dedicated farmers continuing their efforts to develop expertise in medicinal plants cultivation and marketing since 2002.

As a follow up to the achievements of the National Medicinal Plants Board project (2002 – 2006) "*Awareness, training and cultivation of medicinal plants in western U.P*."**,** the farmers have formed a society "*Herbal Agro Development Gramoudyog Society*". This is a commendable step to ensure marketing of medicinal produce & vermicompost. The society includes 40 members of farming community. The society has taken-up plantation of 25000 plants of Amla, in 250 hectare area and cultivation of turmeric, garlic, jatropha, ashwagandha, kalmegh, gheekwar etc in 8 hectare land. A 'mandi' is also being constructed for sale, purchase of herbal produce, vermicompost, horticulture produce. These efforts of society through Shri Dhyan Pal Singh & Shri Nathi Singh, who have encouraged fellow farmers in medicinal plants cultivation, deserve appreciation.

Future research endeavors

The richness of earthworm fauna in the peninsula has wide scope to identify many of the species of earthworms that can be effectively used for conversion of organic waste into compost. Immediate requirement lies in identifying the species

that have tolerance to high moisture content and high temperature to handle the urban solid waste. Similarly the species that can withstand the heavy metal concentration have to be identified to work on organic waste from industries. Earthworms have gained renewed scientific attention in India and abroad for taxonomy because of their wide application in the production of vermicompost, and as a source of animal protein for domesticated animals. However, out of 418 species of earthworms known from India (Julka and Paliwal, 1993) only half a dozen are frequently used for vermiculture and vermin- composting.

Vermicompost production should be standardized by using different plant biomass and animal wastes to obtain high nutrient levels in the compost. The macro and micro nutrient status in the vermicompost needs to be evaluated and research initiated on organic derivatives present in the vermicompst. The step-wise breakdown of the organic matter by the activity of earthworms and associated microbes needs to be studied. This may help in knowing factors that account for resistance to pests and disease of crops and in establishment of seedlings. There is also an urgency to study the earthworm and microbes associations both with respect to beneficial microbes and soil borne pathogens.

Vermicomposting will be economical venture when it is taken up is the vicinity of the waste generating places. It has to be practiced by the farmer himself, rather than buying the compost produced by others. With the available natural resources in the field vermicompost can be produced and it has to be a part of the integrated farming system. Earthworms act as "Ecosystem Engineer" converting a product of 'negative' economic & environmental value *i.e*. 'waste' into a product of 'highly positive' economic & environmental values *i.e*. 'highly nutritive organic fertilizer' (brown gold) and 'safe gold' (green gold).Vermiculture can maintain the global 'human sustainability cycle' producing food back from food & farm wastes(Ismail,2005;Sinha et al.,2008,2009).Earthworms and its metabolic products may work as the 'driving force' in sustainable food production while improving soil health and fertility and protecting crop plants from pests and diseases. They can completely 'replace' the use of agrochemicals in crop production. This is what being termed as 'sustainable agriculture'.

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References

Ismail, S.A., 2005. The Earthworm Book. Other India Press, Apusa, Goa, pp: 101.

Swaminathan, M.S., 2003. The Fight Against Hunger: Report from the Millennium Project Task Force on Hunger, Washington, DC.

Julka, J.M. and Paliwal, R., 1993. Distribution pattern in Indian earthworms In: Earthworm Resources and Vermiculture. *Zoological Survey of India, Solan* PP. 27-31.

Kothari, A., Pathak, N., Anuradha, R. V., Taneja, B. (2001). Communities and conservation: naturaresource management in South and Central

Asia. *International Forestry Review* 3: 76-77.

Sinha, Rajiv K., 2008. Organic Farming: An economic solution for food safety and environmental security. *Green Farming-International J Agricultural Science* 1(10-11):42-49.

Sinha, Rajiv K., Sunil Heart, Ravindra K.Suhane, Pancham, K. Singh, Krunal Chauhan and Dalsukh Valani, 2009. Earthworms Vermicompost: A Powerful Crop Nutrient over the Conventional Compost & Protective Soil Conditioner against the Destructive Chemical Fertilizers for Food Safety and Security Am-Euras. *J. Agric. & Environ. Sci*., 5 (S): 01-55.

Verma, D., Bharti,S., Yadav, S., 2010. Earthworm resources in Gangetic plains of India. *International Journal of Biodiversity and Conservation* 2: 134-139