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Vermi-Composting: An Effective Technique to Recycle Wastes into Valuable Organic Fertilizer: A Review

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Farming system based on chemicals is not sustainable because of many problems such as loss of soil structure, fertility, productivity and deterioration of quality of produce. On the other hand the application of organic fertilizers and manures ensures better soil health, soil structure and enhances growth of beneficial micro organisms. Millions of tons of agricultural and industrial waste are discarded every year at considerable financial and environmental cost. Instead of discarding the food scraps and waste, we can recycle these with the help of earth worms. Vermiculture technology involves the beneficial use of industrial waste which is rich in macro as well as micro nutrients and amount to nearly 320 million tons annually. With the help of vermicomposting we can convert all such waste to wealth by producing highly marketable castings. Research reveals that vermi-technology has a prominent role in the development of ideal soil structure, nutrient and water management, waste management better crop response, plant disease and pest control and production of chief animal protein in the form of earth worms for poultry farming and aquaculture, however incase of vegetable crops vermicomposting is economically feasible instead in cereals.

Keywords: Vermi-composting, organic agriculture and eco-friendly.

Vermiculture (latinvermes = worm,cultura =culture) refers to multiplication of eartworms for various uses and is done on compostable or decomposable organic matter while as vermicomposting is a technology were in earthworms are used as natural bioreactors for the production of vermicompost which is a mixture of worm castings , organic material, humus, living earthworms , their cocoons and other micro organisms. Vermicomposting is a mesophilic process and can be carried out at a temperature of 50-90 degree Fahrenheit. The process is considered faster than composting because material passes through earthworm gut whereby the resulting earthworm casting are abundant in nutrients, plant growth regulators and fortified with pest repellency attributes as well. Vermiculture and vermicomposting are brought about simultaneously. In other words earthworms can be multiplied and vermicast or vermicompost can be obtained in a large quantity at a faster rate provided we have higher number of earthworms available.

Vermiculture has been embraced throughout and world, especially in regions where temperature weather conditions allow for implementation of outdoor systems. In India vermiculture has been employed for waste management and for production of marketable castings. The use of chemical fertilizer and pesticides in order to meet the increasing demand for food is creating a serious threat to the environment and results in an irreversible damage to the ecosystem. So the modern agriculture based on chemical is not sustainable. Therefore a number of alternative systems including use of biofertilizers, biopesticides and organic manures

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have been advocated .similarly vermicomposting not only provides us nutrient rich compost but is extremely helpful in organic waste management. In short earthworms through a type of biological alchemy, are capable of transforming garbage into gold because we get a highly marketable product out of their activity, furthermore with the application of vermicompost in raising crops, soil physical health is improved, humus content in soil increases which increases microflora and fauna, chemical residues in agricultural products is reduced thus ensuring safety against human health hazards and environmental pollution is also prevented.

Taxonomy of earthworms

Earthworms are tabular organisms and are classified under phylum *Annelida*because they have segmented body. Setae are present externally over the body of earthworms ,so these are classified under class *Oligochaeta*(latin : 'oligos' = few; 'chaeta' = heir like). They belong to order '*linicolae*' and there are as many as ten families comprising of 240 genera and about 3320 species . In India there are 509 species of eartworms belonging to 67 different genera.

In vermicomposting commonly used earthworms belong to the following families

No.	Family	Example
1.	Lumbricida	*Eisenia foetida, Eisenia andrae*
2.	Eudrilidae	*Lumbrieus rubellus, Eudrilus eugineae*
3.	Megascolecidae	*Perionyx excavates, Lampito mauritii*
4.	Moniligastridae	*Drawida willsii*

Amongst the above mentioned species of earthworms, *Eisenia foetida* is the world's most widely used earthworm in vermitechnology .Based on their phenology, it is known by different names such as red worm, pink worm, tiger worm or banding worm. One of the reasons for its wide use in vermitechnology is that it tolerates fluctuations in temperature and humidity to greater extent. *Eudrilus eugeneae* (also known as night-crawler) is the fastest growing and 2nd most widely used earthworm because of its high assimilation and biomas conversion ability. *Eisenia foetida* is world's most widely used earthworm. It is highly tolerant to temperature and humidity fluctuations. *Pheretima posthuma* is the most commonly found species of earthworm in india. *Bimastos parvus* is a temperate earthworm and is found in Kashmir. There are so many characters for better composting like High multiplication rate, Resistant to pests and diseases, High efficiency of converting plant or animal biomass to body proteins, Culturing technique should be simple, wide adaptability to environmental conditions, Growth rate should be fast, Feeding preference for wide range of organic materials,High consumption, digestion and assimilation rate.

Vermicompost microflora as influenced by different crop residues

A laboratory survey wasconducted at college of agriculture, Bijapur (Karnataka) to enumerate the microbial load viz., bacteria, fungi, *Azotobacter* and phosphate solubilising microorganisms in vermicompost obtained from different kinds of crop residues.The vermispheremicroflora viz., bacteria, fungi, actinomycetes, Azotobacter and phosphate solubilising microorganisms were estimated by serial dilution and plate count method using agar, Martin's rose Bengal agar with streptomycin sulphate, Kuster's agar, Waksman medium No.77 and Pikovskaya, a medium respectively. Among the different crop residues, vermicompost obtained from sunflower crop residue harboured more bacteria($40x10^5$), actinomycetes ($98.60x10^4$)and phosphate solubilising microorganisms ($25x10^4$),while vermicompost from sugarcane trash was found to have more number of azotobacter($40x10^4$)and fungi($16x10^3$).

However,vermicompost obtained from cow dung harboured highest microbial load viz., bacteria ($73x10^5$), fungi($18x10^3$), actinomycetes ($100x10^4$). Azotobacter ($40.67x 10^4$) and phosphate solubilising microorganisms ($29x10^4$). Higher vermicompost yield was when cow dung was the substrate (759.80kg/bed), followed by sugarcane trash (699.4kg/bed), safflower residue (684.3kg/ bed).The differential yield level of vermicompost with respect to different crop residues indicate that earthworms, the architects of vermicompost have preference towards certain food materials(Zachamann and Linden, 1989 and Hegde, 1995) coupled with the presence of diverse flora of beneficial microorganisms(Jones *et al.*, 2000) contributing to rapid decomposition of crop residues.

Role of vermicuture in crop production

Earthworm play a key role in soil biology as versatile bioreactors . They effectively harness the benefical soil microflora, destroy soil pathogens and convert organic waste into valuable products such as biofertilizers, vitamins, enzymes, antibiotics, growth hormones and proteineous worm biomass. Hence we call the earthworms 'biologicalfertilizer factories' . Role of vermiculture in crop production is discussed under following headings:

Nutrient management

Earthworm modify physical, chemical and bio-chemical properties of soil. They enhance humus production and thus improve physical health of soil and ensure granular or crumb soil structure with adequate soil aeration due to granular structure of their castings. There are abundant evidences to show that the concentration of exchangeable ca, Na , Mg, K, and

Table 1. Effect of vermicompost application on selected microbial population before and after the harvest of paddy crop

Treatment	Bacteria CFU x 10^5	Fungi CFU x10^3	Actinomycetes CFU x10^4	Azotobacter CFU x 10^4	phosphate solubilisers CFU x 10^4	Vermicompost yield (kg/10x1x 0.33mbed size)
1.Cow dung	73.00	18.00	100.00	40.67	29.00	759.80
2.Sugar cane Trash	44.60	16.00	95.65	40.00	23.30	755.40
3.Safflower Residue	40.00	15.00	77.00	40.00	21.68	684.30
4.Pearlmillet Residue	41.33	16.00	85.00	30.32	18.60	699.40
5.Pigeonpea Residue	35.00	15.00	50.00	30.38	15.33	675.40
6.Sunflower Residue	48.00	15.00	98.60	35.00	25.00	702.00
S.Em+	1.59	1.12	1.92	1.47	1.62	23.20
C.D.(0.01%)	6.14	4.49	7.60	5.64	6.38	69.20

[Source: Jones*et al.*, (2001)]

Table 2. Effect of Vermicompost on soil fertility status

Treatments	Organic Carbon(g/kg)	Available status (kg/ha) N	P	K	Fe	Mn	Zn	Cu	CEC [c mol (p+kg-1)
Recommended NPK	7.50	192	11.4	223	45.9	12.2	27.2	2.6	10.88
Cane trash vermicompost @5t/ha+NPK	8.70	237	12.0	458	58.1	13.4	30.1	4.6	13.08
Banana waste vermicompost @ 5t /ha	12.4	231	12.6	371	66.5	14.8	3.9	6.9	14.72
Ipomea vermicompost @5 t/ha +NPK	14.8	290	13.5	362	79.1	15.6	34.9	7.4	18.95
CD (p=0.05)	7.28	36.09	4.77	124	7.5	0.382	7.77	0.86	0.865

Table 3. Effect of vermicompost on yield components of rice

Treatments	Productive Tillers / hill	Panicle length(cm)	Filled grains (%)	Test wt (gm)	Grain yield kg/ha	Straw yield kg/ha
Recommended NPK	7.05	18.64	78.74	17.58	4090	5294
Rice straw Vermicompost	8.25	20.44	81.31	18.64	5135	6203
Sugarcane trash Vermicompost	9.15	20.77	82.37	19.01	5551	6898
Water hyacinth Vermicompost	10.06	21.23	84.03	19.36	6315	7799
CD (P=0.05)	0.77	0.19	0.72	0.16	494	616

Source: Sudhakar (2000)

available N, P and Mo are higher in earthworm castings than in soil.

Vermicompost is a good carrier for many bacteria like Rhizobium, Azospirillum ,Azotobacter, phosphorus solubilising bacteria besides plant nutrients. Earthworm activities have also important role in maintenance of C:N AND C:P ratios in the soil favouring the growth of other soil microorganisms. Soil enrichment is also achieved by speeding up mineralisation of organic matter two to five times more than normal.

Water management

Earthworm affect the pore space in the soil by burrowing and depositing their cast as loosely packed aggregates on the soil surface. Earthworms numbering 0.2-0.5 million per hectare, make permanent structurally table burrows, and numbering 0.5 to 1.0 million per hectare, allows water infiltration upto 120 mm/ha. Hence ,inspite of heavy spells of rain, there is hardly any runoff and soil erosion, as each burrow acts as a microdam.

Table 4. Grain yield of rice as influenced by vermicompost and fertilisers

Treaments	Grain yield (q/ha)
Recommended dose of NPK(100:50:50)	52.22
Vermicompost @ 10t/ha	47.61
FYM@ 10 t/ha	45.70
Glyricidia @10 t/ha	45.82
Vermicompost @ 10 t/ha +50 % recommended dose of NPK	63.06
FYM @10t/ha + 50 % recommended dose of NPK	62.71
Glyricidia @10 t/ha+ 50 % recommended dose of NPK	60.90
C.D at 5%	9.37

Source : Anonmyous (1996)

Earthworm cast being granular and with enhanced internal porosity absorbs moisture particularly during night and hold it effectively for releasing to micro-roots of the vegetation (Jat and Kumar , 2002).

Role as a bio-pump

Earthworm's burrow enhances water infiltration and storage over a considerable depth of soil. Earthworms help to bring this moisture to upper layers by acting as bio pump. They produce biological water during the decomposition of organic matter. This 'slow release' water can be effectively utilised by the roots.

Waste management

vermitechnology is being harnessed to set up units for cost –effective treatment of various non-toxic organic solid and liquid wastes including crop residues and vegetable wastes. The potential waste biomass resource as available in India has been estimated to be 2 billion tonnes per year. This amounts to 13.96 million tonnes of plant nutrients. Thus a through utilisation of these organic wastes in India may help in bringing fertilizer gap and saving as well as earning foreign exchange and taking care of organic pollution (Jat and Kumar, 2002).

Disease and pest control

Healthy soil has a balanced population of benefical soil microflora and burrowingearthworms. This reduces the population of soil pathogens through competition and antibiosis. The 'take all' disease of wheat caused by *pseudomonas coirugate* can be controlled by the presence of earthworms. Recently laboratory data have shown that the activity of *Rhizoctonisolani* substantially decreased in presence of earthworms. Thus earthworms act as bio-pesticides.

Table 5. Effect of vermicompost on growth and yield of green gram

Treatments	Yield(g/pot)		Root wt.	Nodule dry wt.	Nutrient in plant(%)		
	Seed	Dry Matter	(g / plant)	(mg/plant)	N	P	K
*RDN as urea	5.2	10.2	0.23	13.7	1.44	0.39	1.02
RDN as vermicompost	7.7	13.8	0.56	26.1	1.49	0.42	1.10
RDN as FYM	5.7	11.1	0.35	22.5	1.38	0.39	1.06
CD (P=0.05)	0.8	1.8	0.03	1.7	0.17	0.04	0.06

Source : Rajkhowa *et al.* (2000)

Earthworm as vector of beneficial micro-organisms

One of the major constraints for effective root colonization by beneficial soil bacteria is their limited capacity for unaided dispersal through soil. A number of methods have been used to inoculate beneficial micro-organisms, into the soil(e.g. seed inoculation), But these procedures, when used in the field, commonly inoculate only a small portion of soil volume which is available to the plant roots. The activity of the earthworms has been shown to promote the dispersal through the soil variety of beneficial soil micro-organisms including Pseudomonas, Rhizobia and Mycorrhizal fungi which ultimately help in enhancing soil fertility and plant growth and development. The vermicompost is also a good carrier of these micro-organisms. Earthworms are also important agents in the distribution of VAM fungi thereby influencing plant establishment in early sucession.

Pollution abatement

Vermiculture provides a tool for use in recycling of degradable organic wastes into useful products i.e, vermicompost. Earthworms have capacity to accumulate and bind heavy metal and this helps to abate the pollution. However, further studies are needed in this direction.

Crop response

Increase in crop yield and quality has often been recorded in plants grown in presence of earthworm casts. It is evident that organically produced agricultural products are nutritionally superior, good in taste and better in keeping quality when vermicompost is applied . the influence of earthworm cast on nitrogen metabolism has been directly made evident by an increased protein content in the plants. The response of various crops to vermicompost has been found very encouraging. The results of trials conducted at various research stations have projected the biological efficiency of about two times higher than normal yield and marked with a distinction in quality.

Vermicompost has been found to be an excellent source of nutrients for rice (Edwards, 1998).compared to chemical fertilizers application of paddy (IR-20) improved the vegetative growth including shoot weight, root weight, root and shoot length (Kale and bono, 1996). The paddy field that received vermicompost as an organic amendment showed significant increase in the colonization of N –fixers , actinomycetes and spore formers. The per cent mycorrhizal colonization in the roots was 10% in the experimental plots receiving vermicompost. The application of vermicompost has enhanced the activity of these microbes in the soil system, the chemical fertilizer application can be brought down by 25-50% when it is used with vermicompost. Applying vermicompost to low land rice improved nutrient uptake, increased level of N,P and microbial load and higher level of symbiotic association resulted

Table 6. Tuber yield (kg/plant) and (q/ha) as affected by planting dates and nutrition level

Treatment	Tuber yield (kg/plant) 2008	2009	Tuber yield (q/ha) 2008	2009	Pooled
Planting dates					
11th SMW (10th Mar)-D1	0.333	0.403	278.76	336.12	307.11
13th SMW (25th Mar)-D2	0.420	0.437	350.71	364.36	357.19
15th SMW (11th Mar)-D3	0.296	0.300	247.12	250.06	248.33
CD(P=0.05)	0.05	0.002	10.22	11.12	10.18
Nutrition levels					
RDF(160:100:100 N P K Kg/hac)	0.339	0.371	282.96	309.07	296.00
70%RDF+20t/ha FYM	0.347	0.378	289.36	314.89	304.52
70%RDF+8t/ha	0.356	0.384	298.28	320.48	309.18
70%RDF + Azotobacter and PSB	0.313	0.349	261.49	290.99	276.08
70%RDF + 20t/ha FYM+Azotobacter and PSB	0.366	0.392	305.51	327.09	316.12
70%RDF + 8 t/haVC+Azotobacter and PSB	0.378	0.406	315.57	338.55	326.00
CD(P=0.05)	0.03	0.002	7.9	8.62	7.89

Source : (Sumati Narayan, 2007)

in increased effect on growth and yield (Kale et al., 1992). When applied to dried sown rice, the seedlings turned dark green immediately after emergence (Gunathilagaraj, 1994). It indicates that application of vermicompost had immediate benefits as the nutrients can be directly absorbed.

Angadi and Radder (1996) were able to save 50% of the recommended NPK fertilizer in upland rice by applying 2.5t/ha of vermicompost. The grain yield was significantly higher in crop receiving vermicompost @ 5t/ha +NPK at the recommended dose compared to treatment receiving NPK alone. Integrated application of organic N through vermicompost, fertilizer N and bio-fertilizer enhanced the growth parameters, yield attributes and yield of rice (Jayabal and Kuppuswamy, 1997). Tested vermicompost for its ability to replace a proportion of the urea fertilizer supplying one third to one quarter of nitrogen as vermicompost increased plant height , grain yield and yiel components of rice. (Table 5).Nagarajan (1997) obtained higher net income by application of vermicompost in rice.

Tomato et al. (1983) reported that earthworm cast which is rich in available nutrients increased the plant- growth and yield of crop. Though Kale and Bano (1984) reported that differences in grain yield of rice between the treatment plots receiving vermicompost @ 1.5 t/ha and inorganic fertilizers such as urea @ 100kg N/ha plus suphala (15:15:15) @ 200 kg/ha were statistically at par. In another experiment, an application of vermicompost @10 t/ha +50 per cent recommended dose of NPK produced 63.06 q/ha or rice yield which was significantly higher over the treatment receiving recommended dose of NPK (52.22 q/ha) (Annonymous,1996)(Table 6.)

Application of vermicompost showed significant positive effect on yield , dry matter production, nutrient content in plant and nodule dry weight /plant in green gram.(Table 7). The application of vermicompost gave higher germination (93%) of mung bean (*Vignaradiata*) compared to the control (84%). Further the growth and yield of mung bean was also significantly higher with vermicompost application.

Profitability of vermicompost enterprise

Vermicomposting is an profitable enterprise and generates income and employment. Vermicomposting is very useful method for conversion of ruler and urban organic waste into good quality manure. The soil enriched with vermicompost provides additional substances that are not found in the chemical fertilizers. The multi farious effects of vermicompost influence the growth and yield of crops for a viable vermicomposting following is the estimated cost:

Estimate for construction of 10 sq. m vermicompost structure:

Non recurring expenditure	
1, Construction of structure	= Rs 14000/-
2, Roofing with tin sheds	= Rs 10,000/-
3, Cost of 10 kg earthworms @ 500 per kg	= Rs 5000/-
Total	**= Rs 29000/-**
Recurring expenditure	
1, Dry organic matter 3 qt. @ Rs 50 per qt.	= Rs 150/-
2, Farm yard manure 4 qt. @ Rs 100 per qt.	= Rs 400/-
3, Maintenance charges	= Rs 2000/-
Total	**= Rs 2550**
• Recurring expenditure is 8 times in a year	= 2550×8 = **Rs 20400**

Total

Non recurring expenditure = Rs 29000/-

Recurring expenditure = Rs 20400/-

Total = Rs 49400/-

Returns

1, Production of vermicompost 50 qt.@ Rs 400/qt. =Rs20000/-

2, Average production of earthworms in one year 2.5qt. @ Rs2500/qt =Rs 62500/-
Total = Rs 82500/-
Net Income 82500- 49400 = Rs 33100/-

CONCLUSION

Vermiculture is a profitable enterprise and is presently widely embraced worldwide for various uses. In India Vermitechnology has a great scope particularly in temperate region of Kashmir valley where the environmental conditions are feasible for setting up vermicomposting units on a large scale. It needs an exhaustive research to establish the feasibility of locally available earthworm species for vermicomposting further more earth worm species have a wide range of adaptability need to be identified. Vermicomposting can also support other allied agricultural enterprise to flourish such as aquaculture and poultry farming by supplying feed in the form of live earth worms. Therefore, vermiculture enhances adoptibilty of mixed farming. Research has revealed a significantly favourable response of vegetable crops to vermicompost. However, research on feasibility of organic farming based on vermicomposting under Kashmir conditions is going on in SKUAST-K to establish scientific recommendations with respect to vermicompost application for growing of various crops.

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