ISSN 0976 – 3333

Available Online at www.ijpba.info

International Journal of Pharmaceutical & Biological Archives 2011; 2(6):1615-1620

REVIEW ARTICLE

Vermicompost – A Soil Conditioner cum Nutrient Supplier

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Received 27 Aug 2011; Revised 06 Nov 2011; Accepted 15 Nov 2011

ABSTRACT

Composting, generally defined as the biological aerobic transformation of an organic by-product into a different organic product that can be added to the soil without detrimental effects on crop growth. 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. Vermicompost is derived by rearing worms on organic work mixed with cattle dung. It contains plant nutrient like N, P, K, Ca, Mg, Fe, Mn and Zn which has a positive effect on the plant growth, yield, soil fertility and soil microbes. This present review paper revealed the various dynamic of the soil – plant relationship with special emphasis on vermicompost. This review assesses the following topics: effect of vermicompost on soil property and application of vermicompost.

Key words: Vermicompost (VC), Soil microbes, Sustainable agriculture.

1. INTRODUCTION

The long – term use of inorganic fertilizers without organic supplements damages the soil physical, chemical and biological properties and cause environmental pollution [1]. Vermicompost contains a high proportion of humic substances (that is, humic acids, fulvic acids and humin) which provide numerous sites for chemical reception. Microbial components known to enhance plant growth and disease suppression through the activities of bacteria, yeast and fungi, as well as chemical antagonists such as phenols and amino acids [2]. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil [1].

2. EFFECT ON VERMICOMPOST SOIL FERTILITY

2.1. Effect of vermicompost on nutrients and microbial population

Soil microorganisms play an important role in improving soil fertility and crop productivity due to their capability of fixing atmospheric nitrogen, solublizing insoluble phosphorus and decomposing farm wastes resulting in the release of plant nutrients [3]. There are varying reports on the nutrient contents of vermicasts [4] whereas Rao *et al.* [5] ascertained vermicompost nutrient values for a good vermicompost based on their study on urban wastes and also suggested the rate of application of vermicompost (**Table 1**). Along with soil microorganisms, the addition of vermicompost also benefits the soil fertility in terms of nutrients and microbial population, as presented next.

Teotia *et al.* [6] reported a 3.4 - to 5.4 - fold increase in bacteria compared to the surrounding soil. Ghilarov [7] claimed that the number of microorganisms in earth worm casts was 1.64-, 1.35- and 1.97-fold higher than in regular soil in three different fields, namely oak forest, rye wand grass, respectively. A 5- and 40-fold higher level of bacterial counts was reported in vermicasts more than the surrounding soil in the case of potato peel waste [8] and paper industry sludge [9] respectively. An increase in hydrolytic microflora in vermicomposting of organic solid wastes was reported by [10, 11]. The moisture content of vermicompost is an essential environmental condition for the survival of beneficial microorganisms, irrespective of whether earth worms continue to live or not. The decrease in moisture content will bring down the level of CFUs (colony forming units) and organic carbon [12].

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A study on microbes in the gut of earthworms revealed an increase in the number of bacteria and actinomycetes compared to soil, following an exponential law [14]. In general, the level of micro-organisms in the gut and vermicasts of earthworms can be used as one of the measures to evaluate vermicompost, allowing us to say that earthworms are important in inoculating the soil and their casts are the foci for dissemination of soil microorganisms, which will elevate the overall fertility of soil. Monson *et al.* [15] reported an increase in nutrients of kitchen waste vermicomposted by *E. eugeniae* nigrogen content, from 1.31 to 2.12%; phosphoms, from 0.121 to 0.7%; potassium, from 0.45 to 0.48% and the C: N ratio decreased from 32.45 to 13.66%. A significantly higher number of microbes were observed in experimental plots treated with vermicompost nitrogen. N-fixing bacteria were also higher in plots to which vermicompost was applied after harvest of the crop. A higher microbial load was also observed in paddy field to which vermicompost was applied [16]. An increase in the microbial population was recorded with potato waste using *Pheritima elongate* [8] and with pressmud waste using *E. fetida*, *E. eugeniae* and *Megascolex megascolex* when compared with the surrounding soil [11]. Meena and Renu [17] reported a increase in nutrients when press mud was blended with raw dust and treated using three different earthworm species *E. fetida*, *E. eugeniae* and *P. excavatus* individually (mono cultures) and in combination (polycultures).

The effect of vermicompost on the microbial population in a soil environment was reported to be best with vermicompost prepared out of a combination of leaf litter, straw, grass and water hyacinth compared to vermicomposted leaf litter, home garbage and partially decomposed cow dung (VC4) when applied at a rate of 5% (w/w). The fold increase was 2.16, 1.83, 1.71 and 1.69 in bacteria, 1.49, 1.30, 1.52 and 1.40 in actinomycetes, 2.89, 2.76, 2.38 and 2.47 in fungi for VC1, VC2, VC3, VC4, respectively [18]. Fragoso *et al.* [19] also reported similar findings. Kale *et al.* [16] reported that earthworm burrows lined with earthworm casts are an excellent medium for harboring nitrogen fixing bacteria Bhattacharya *et al.* [20] also recorded an increase in the microbial count in when vermicomposts compared to traditional compost (**Table 2**). The major part of inorganic nitrogen occurred as ammonia, which was rapidly converted to nitrate [14]. Kumar [21] reported the contents of vermicomposts (**Table 3**). The characteristics of separated human faeces and vermicompost prepared out of source separated human faeces by precomposting faeces using bulk amount of *E. fetida* (**Table 4**) showed that pathogens were eliminated and nutrients were enhanced [22].

The water-holding capacity of soil increased due to an increase in colloidal materials like earthworm mucus, a good absorbing agent in vermicompost, and the polysaccharide content of earthworm casts was much higher than the soil but did not vary with changes in stability of total and mineral Nitrogen. Earthworms increased the water-holding capacity of New Zealand soils by about 17% [23].

E. fetida vermicasts from sheep manure alone and mixed with cotton wastes were analyzed for their properties and chemical composition every 2 weeks for 3 months and compared with the same manure without earthworms. Earthworms accelerated the mineralization rate and resulted in castings with a higher nutritional value and degree of humification, suggesting that this kind of industrial waste can be used in vermicomposting [25]. Similarly, accelerated mineralization and humification of solid paper pulp mill sludge with earthworms in comparison to without earthworms was reported by Elvira *et al.* [26]. Athanasopoulos [27] used vermitechnology to manage aerobically stabilized effluents of the dried vine fruit industry using *L. rubellus*. The COD removal was 95% with 0.1 loading and 0.15 Kg COD/m^{-2} d.

Table 1: Composition of good quality vermicompost and rate of application for various crops

Parameter	Vermi compos	Crop	Rate (Th^{-1})
pH	7-8.5	Cereals	12.5
Organic carbon (%)	20-30	Pulses	10
Nitrogen (%)	1.5-2.0	Oil seeds	12.5
Phosphorus (%)	1-2	Spices	10
Potassium (%)	1-2	Vegetables	12.5
Calcium (%)	1-3	Fruits	7.5
Manganese (pap)	1-2	Cash crops	15-17.5
Sculpture (%)	<1	Plantations	7.5
Moisture (%)	15-20	* Horticulture crops	100-200 g/tree
C/N ratio	15-20: 1	* Kitchen garden and pots	50g/pot
Micronutrients (pap)	200		

Sources: * Purakayastha and Bhatnagar [13]

Table 2 Comparison of microbial counts of traditional and vermicomposts

Type of microbes	Traditional compost	Vermicompost
Bacteria	$143 \times 10^{+7}$ g^{-1}	167.29×10^{5} g^{-1}
Fungi	39.61×10^{5} g^{-1}	96.25×10^{5} g^{-1}
Actinomycetes	365.27×10^{6} g^{-1}	419.62×10^{5} g^{-1}
PP solution	195.61×10^{5} g^{-1}	168.20×10^{5} g^{-1}
N, fixing bacteria	92.58×10^{5} g^{-1}	96.62×10^{5} g^{-1}
Thio-sulphate oxidizer	315.38×10^{5} g^{-1}	569.29×10^{5} g^{-1}

Source: Bhattacharya *et al.* [20]

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Table 3 : Vermicompost contents

Humus	30-50%
N	0.72%
K	0.74%
Carbon	40-57%
Hydrogen	4-8%
Oxygen	33-54%
pH	4 to 9
C/N	20

Source: Senthil Kumar [24]

Table 4 Comparison of characteristics of human faeces and its vermicomposts

Parameters	[a]Values for faeces	[a]Vermicompost of faeces
Moisture content (%)	80 ± 5	43 ± 5
Bulk density (Kg/M^3)	1200 ± 200	720 ± 100
pH	5.3 ± 0.2	8.0 ± 0.3
Electrical conductivity (mmho/cm)	60 ± 15.0	28.5 ± 3.0
Total Nitrogen (mg/g dry weight)	41 ± 4.0	28 ± 0.2
Total organic carbon (mg/g dry weight)	415 ± 15	175 ± 10
C:N	10.5 ± 1.0	6.5 ± 0.5
Phosphorous as P_2O_5 (mg/g dry weight)	11 ± 2.0	23.5 ± 2.5
Potassium as K_2O (mg/g dry weight)	28.0 ± 1.7	65.0 ± 7.5
Total coli forms (MPN/g)	5.0 x 10^9	<3.6

[a]Values are mean ± standard deviation based on 48 samples

3. APPLICATION OF VERMICOMPOSTS

3.1. Crop growth and yield

This review will now cover the application of vermicomposts with special emphasis on fruit-bearing plants and their yield. Banana plants grow well when vermicompost was applied [28] with having a mean bunch weight of 15kg / plant, more fingers/branch and more reducing sugars. Vermicompost at a rate of 250.000 worms / ha resulted in a significantly reduced harvesting time in “Rajapuri” banana [29]. Venkatesh *et al.* [30] revealed that *insitu* vermiculture and use of vermicompost with graded levels of chemical fertilizers of vermicompost alone increased the yield of grapes (*V. vinifera*) significantly more than the control, which had also been reported earlier [31]. Application of vermicompost at 2.5 t/ha was reported to significantly increase the yield, sweetness and reduce the harvesting period when compared to the control, where as application in combination with neem cake gave significantly higher and better yield than control and higher yield, improved quality of custard apple (*Annono squamosa*) [32] by soil application of vermicompost.

The application of vermicompost increased the growth and yield of peppers (*Piper nigrum*) significantly, including increased leaf area, plant shoot biomass and marketable fruit weights [33]. Sanwal *et al.* [34] observed that tomato (*Solanum lycopersicum*) and okra (*Hibiscus esculcnta*) were also reported with high growth and yield parameters when vermicompost was applied [35]. Prabha [36] showed that growth parameters (root length, shoot length, number leaves) of vegetables like *Hibiscus esculenta* and *Solanum melongena* and medicinal plants like (*Adhatoda vasica* and *Solanum trilobatum* showed higher values in vermicompost applied after 90 days, the germination percentage was also higher in vegetable peanuts to which vermicompost was applied.

The application of vermicompost provided better yield than other organic manures and the control in marigold (*Calendula officinalis*) as reported by [37]. A laboratory experiment conducted using *Octolasion tyrtacum* on maize, barley and wheat showed better growth parameters of shoot and root [38]. Yield of (*Alliam cepa*) increased significantly when 100 and 50% nitrogen was applied through vermicompost produced by *E.eugeniae* using decomposed leaf powder along with 50 kg/ha, phosphorus potassium + 50 kg/ha, k in separate plots [5].

The rate of application of earthworms for *in situ* vermiculture along with the species employed and application of vermicompost, which have shown growth and yield attributes (increase in height, mean bunch weight, leaves, fruits, nutrients) for horticultural crops suggest the significance of vermicompost in the field of agriculture and food production, which is of prime importance for a developing country like India.

3.2. Sustainable agriculture

Sustainable agriculture is the management of resources for agriculture to satisfy changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources [39]. Vermitechnology can be a successful tool for utilizing agricultural residues and livestock dung to obtain valuable organic manure, vermicompost, which is a peoples acceptance of ecological principle through low input agriculture which can be used to tackle many serious problems affecting food production [5]. For successful promotion of sustainable agriculture components like improving productivity [40] crop diversity, integrated management of soil nutrients and crop pests, water management, suitable post harvesting technology and sound extension programmes need to be considered. This includes convincing rural populations to adopt different technologies like vermicompost and use production of biogas by individuals leading to sustainability in agriculture use that would of also indirectly alleviate poverty and ultimately increase the quality of life [41].

4.CONCLUSION AND FUTURE PROSPECTS

In recent years the ecological characteristics and beneficial effects of earthworms have been clearly demonstrated, focused by scientific research. Earthworms activity influences the rate of soil organic matter. Improvements in the consistency of soil texture with a concomitant increase in porosity, infiltration and soil – water retention are other characteristics of worm worked soils [11]. Many developed countries like the USA, UK and Japan have large scale manufacture of vermicompost from agriculture, municipal and industrial organic wastes on commercial basis [42]. As far as scientific communities are concerned, there is an urgent need to develop research in the field understanding biodegradation of organic matter by earthworms and microorganisms. The microbes isolated from vermicompost could separately be tested for biodegradation. The use of consortia developed based on enzyme activities and characteristics as particular industrial wastes could be used for designing an industrial waste treatment unit [11]. The application of vermicompost for increasing crop yield is region – wise based on the type of crops grown along with standard dosage of application [43]. Thus an application of vermicompost not only enrich the nutrient status of soil but also elevates the physical condition of it.

ACKNOWLEDGEMENT

The authors are deeply indebted to staff of Departments of Agronomy, Soil Science and Chemistry, Agricultural Microbiology. The authors are grateful to the Professor and Head, Department of Zoology, Annamalai University and Tamil Nadu Government Agriculture Department, Cuddalore for their unspiring help and constant support for providing adequate laboratory facilities to carry out this research work.

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