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Significance of vermicompost on crop and soil productivity: A review

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Abstract
Soil performs ecological services for the survival and nourishment of life. So, maintaining and improving soil health has paramount importance for sustainability of ecosystem. Indiscriminate use of the inorganic fertilizer, pesticide has harmful effects on soil health, human health, ground water health and environment. This will caused more dangerous effect for future possibility. Present status of all food grain production is in enough quantity for population of our country so we need to improve quality of food production, quality of soil, quality of ground water and quality or healthy environment for better livelihood. These qualities are obtained by the replacing inorganic input through organic input which is more vital for present prospect and future outlook. This review paper attempts to study the use of vermicompost in crop production. It has been argued that vermicompost in crop production is productive and sustainable, but there is a need for strong support to it in the form of manifestation of subsidies, agricultural extension services and research.

Keywords: Soil, vermicompost, soil health, human health

Introduction
Agro-industrial sector contributes huge resources of plants nutrients in the form of wastes like animal manure, food waste, sewage sludge and industrial organic wastes which is either terrified away or burnt causing environmental pollution. Conventional composting of press mud takes about half a year and has less nutritive value. Decomposition of these waste by using different species of earthworms *Eisenia foetida, Lampito mauritii, Eudrilus eugeniae* and *Perionyx excavates* can be converted into an eco-friendly organic manure soil amendment and these vermicompost shows ample plant nutrient content and enzymatic microbial activities facilitating the easy uptake by the plants (Parthasarthi and Ranganathan, 2002) [40]. Vermicomposting is an economically and environmentally friendly process of decomposition of organic waste. Vermicompost is a very nutritive organic manure having ample amount of humus, nitrogen (N) 2–3% phosphorous (P) 1.55–2.25%, potassium (K) 1.85–2.25%, micro nutrients, and soil microbes like 'nitrogen fixing bacteria' and mycorrhizal fungi. Vermicompost has been scientifically proved as miracle plant growth enhancer (Chaoui *et al.*, 2003) [18]. Ansari and Ismail (2012) [3] reported that worm's vermicompost contains 7.37% nitrogen and 19.58% phosphorous as P2O5. Microbial population of N2-fixing bacteria and Actinomycetes increases after application of vermicompost. The intensified microbial activities improve the availability of soil phosphorous, nitrogen and micro nutrients (Chanda *et al.*, 2011) [17]. Vermicompost stimulates to influence the microbial activity of soil, improve water holding capacity of soil, increases the availability of oxygen, increases soil porosity and infiltration of water, maintain soil temperature, improves nutrient content and increases growth, yield and quality of the plant (Arora *et al.*, 2011) [9].
Extensive usage of inorganic fertilizers and pesticides in agriculture has lead to environmental problem like pesticide residue in food, bioaccumulation and biomagnifications of pesticides in food web and deterioration of soil health. Owing to wide spectrum of problems with the use of chemical fertilizer, organic farming is becoming popular among the farming community. Vermicompost play a significant role in organic-based farming system such as organic farming or sustainable farming and in numerous ways account for crop nourishment, soil productivity enhancement and providing sustainability to farming system (Varghese and Prabha, 2014) [54].

Here we have emphasized different positive aspect of vermicompost one by one for easily understanding.

Effects of Vermicompost on Plant Growth and its final product

Vermicompost plays a major role in improving growth and yield of different field crops, vegetables, flower and fruit crops. The application of vermicompost gave higher germination (93%) of mung bean compared with bio digested slurry (84%). Further, the growth and yield of mung bean was also significantly higher with vermicompost application (Karmegam *et al.*, 1999) [33]. Likewise, in another pot experiment, the fresh and dry matter yields of cowpea were higher when soil was amended with vermicompost than with biodigested slurry (Karmegam and Daniel, 2000) [33]. The application of vermicompost along with fertilizer N gave higher dry matter (16.2 g $plant^{-1}$) and grain yield (3.6 t ha^{-1}) of wheat and higher dry matter yield (0.66 g $plant^{-1}$) of the following coriander crop in sequential cropping system(Verma *et al*., 2017) [58]. Similarly, a positive response was obtained with the application of vermicompost to other field crops such as sorghum (Patil and Sheelavantar, 2000) [41] and sunflower (Devi and Agarwal, 1998) [20]. Application of vermicompost at 5 t ha^{-1} significantly increased yield of tomato (5.8 t ha^{-1}) compared to application of farmyard manure (3.5 t ha^{-1}) (Verma *et al*., 2017) [58]. Similarly, greenhouse studies have indicated that vermicompost enhances transplant growth rate of vegetables. Amendment of vermicompost to vegetables had the highest amount of red marketable fruit at harvest. In addition, there were no symptoms of early blight lesions on the fruit at harvest. The yield of pea was also higher with the application of vermicompost (10 t ha^{-1}) along with recommended N, P and K than with these fertilizers alone (Reddy *et al.*, 1998) [45]. Vadiraj *et al*., (1998) reported that application of vermicompost produced herbage yields of coriander cultivars that were comparable to those obtained with chemical fertilizers. Nethra *et al*, (1999) [39] reported that the fresh weight of flowers of Chrysanthemum chinensis increased with the application of different levels of vermicompost. Also, the number of flowers per plant (26), flower diameter (6 cm) and yield (0.5 t ha^{-1}) were maximum with the application of 10 t ha^{-1} of vermicompost along with 50% of recommended dose of NPK fertilizer. However, the vase life of flowers (11 days) was high with the combined application of vermicompost at 15 t ha^{-1} and 50% of recommended dose of NPK fertilizer. An experiment conducted by Alam *et al.*, 2007 [2], to study the effect of vermicompost and NPKS fertilizers on growth and yield of potato (cv. Cardinal) in Bangladesh, suggested that 100% inorganic fertilizers with 5-10 t ha^{-1} of vermicompost is suitable for higher production of potato and economically profitable.

In the present study vermicompost produced significant improvements in the growth and yield of sweet corn, as also reported by Atiyeh *et al.*, (2000) [11], Arancon *et al.*, (2004) [7] and Singh *et al*., (2008) [50], Verma *et al*., (2017) [58]. Replacement of 25% of the nutrients provided to the plants by vermicompost produced significant greater increases in plant height and marketable crop yield than those produced by 100% inorganic fertilization. Nevertheless the magnitude of such effects was relatively small and not general, with a large degree of variability between the different hybrids assayed. Furthermore, there was little or no difference from the effects produced by manure on plant height and crop yield. Interestingly, increases in sweet corn growth and marketable yield were produced by both the normal and the high doses of vermicompost and manure, indicating that these effects were independent of the amount of N, P and K provided. Foliar analysis revealed that the differences in macronutrient content between the plants cultivated with the three types of fertilizers were minor. However, plants cultivated with vermicompost showed a slightly higher foliar P content. The same amounts of nutrients (NPK) were supplied with each dose of the three fertilizers and therefore the higher foliar phosphor us content in plants amended with vermicompost presumably corresponds to greater availability of this nutrient in the soil.

Vermicompost significantly stimulates the growth of a wide range of plant species including several horticultural crops such as tomato (Hashemimajd *et al*., 2004; Gutiérrez-Miceli *et al*., 2007, Verma *et al*., 2018) [26, 25, 56-57], pepper (Arancon *et al*., 2005) [6], garlic (Argüello *et al*., 2006) [8], aubergine (Gajalakshmi and Abbasi, 2004) [23], strawberry (Arancon *et al*., 2004) [7], sweet corn and green gram (Karmegam *et al*., 1999) [33]. Vermicompost has also been found to have positive effects on some aromatic and medicinal plants (Anwar *et al*., 2005; Prabha *et al*., 2007) [4, 43], cereals such as sorghum and rice (Bhattacharjee *et al*., 2001; Reddy and Ohkura, 2004; Sunil *et al*., 2005) [13, 45, 52], fruit crops such as banana and papaya (Cabanas-Echevarria, *et al*., 2005) [14], and ornamentals such as geranium (Chand *et al*., 2007) [16], marigolds (Atiyeh *et al*., 2002) [10], petunia (Arancon *et al*., 2008) [5], chrysanthemum (Hidalgo and Harkess, 2002a) [27] and poinsettia (Hidalgo and Harkess, 2002b) [28]. Positive effects of vermicompost have also been observed in forestry species such as acacia, eucalyptus and pine tree (Donald and Visser, 1989, Lazcano *et al*., 2010, Verma *et al*., 2018) [21, 35, 56-57]. Vermicompost has been found to have beneficial effects when used as a total or partial substitute for mineral fertilizer in peat-based artificial greenhouse potting media and as soil amendments in field studies. Likewise, some studies show that vermicomposting leachates or vermicompost water-extracts, used as substrate amendments or foliar sprays, also promote the growth of tomato plants (Tejada *et al*., 2008, Verma *et al*., 2018, Verma, 2016) [53, 56-57, 55], sorghum (Gutiérrez-Miceli *et al*., 2008) [24], and strawberries (Singh *et al*., 2010) [49]. Positive effects of vermicompost include stimulated seed germination in several plant species such as green gram (Karmegam *et al*., 1999) [33], tomato plants (Zaller, 2007) [60], petunia (Arancon *et al*., 2008) [5] and pine trees (Lazcano *et al*., 2010) [35]. Vermicompost also has a positive effect on vegetative growth, stimulating shoot and root development (Edwards *et al*., 2004) [7]. The effects include alterations in seedling morphology such as increased leaf area and root branching (Lazcano *et al*., 2009) [34]. Vermicompost has also been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced (Atiyeh *et al*., 2002; Arancon *et al*., 2008) [10, 5], as well as increasing fruit yield (Atiyeh, *et al*., 2000; Arancon *et al*., 2004; Singh *et al*., 2008 [50],Verma *et al*., 2018, Verma, 2016) [11, 7, 56-57, 55]. In addition to increasing plant growth and productivity, vermicompost may also increase the nutritional quality of some vegetable crops such as tomatoes (Gutiérrez-Miceli *et al*., 2007) [25], Chinese cabbage (Wang *et al*., 2010) [59], spinach (Peyvast *et al*., 2008) [42], strawberries (Singh *et al*., 2008) [50], lettuce (Coria- Cayupán *et al*., 2009) [19], and sweet corn (Lazcano *et al*., 2011, Verma *et al*., 2018, Verma, 2016) [56-57, 55]. Nevertheless, despite the large body of scientific evidence showing the positive effects of vermicompost on plant growth and yield, there is also strong evidence that these effects are not general or constant, and that there is great variability in the magnitude of the effects reported in different studies. In fact, some studies report that vermicompost may decrease growth and even cause plant death (Roberts *et al*., 2007) [46]. The variability in the effects of vermicompost may depend on the cultivation system into which it is incorporated, as well as on the physical, chemical and biological characteristics of vermicompost, which vary widely depending on the original feedstock, the earthworm species used, the production process, and the age of vermicompost (Rodda *et al*., 2006; Roberts et al., 2007) [47, 46]. There is also a large variation in the effects of vermicompost depending on the plant species or even the variety considered. This was observed in tomato plants where the replacement of a fertilized commercial potting media with vermicompost had different effects on germination, seedling elongation, biomass allocation, fruit morphology and chemical properties of three tomato varieties (Zaller, 2007, Verma *et al*., 2018, Verma, 2016,) [60, 56-57, 55]. Similar variation was observed in an experiment studying the effects of vermicompost and vermicompost extracts on the germination and early growth of six different progenies of maritime pine Lazcano *et al*. (2010) [35]. Same study revealed that the speed of maturation increased with vermicompost, relative to the control, in three out of the six pine progenies, decreased in two of the progenies and was unaffected in the other. It may be expected that different hybrids or plant genotypes will respond differently to vermicompost, considering that plant genotype determines important differences in nutrient uptake capacity, nutrient use efficiency and resource allocation within the plant. Different genotypes may therefore enhance root growth or modify root exudation patterns in order to increase nutrient uptake (Kabir *et al*., 1998; Cavani and Mimmo, 2007) [30, 15], and all of these strategies will determine the establishment of different interactions with the microbial communities at the rhizosphere level. In fact, after the application of vermicompost to sweet corn crops, the different genotypes showed important differences in their rhizosphere microbial community (Aira *et al*., 2010) [1]. In light of this evidence, it is clear that vermicompost constitutes a promising alternative to inorganic fertilizers in promoting plant growth. However, further research into the exact mechanisms and circumstances that stimulate plant growth by this organic substrate is necessary in order to maintain consumer confidence in this type of fertilizer.

Effect of Vermicompost on Nutrient Uptake

The earthworms are the agents of turning, fragmentation and aeration. It also increase N_2 fixation by both nodular and free living N_2 fixing bacteria result enhance plant growth. Vermicompost has been proved as cheapest source of nitrogen and other essential elements for better nodulation and yield particularly in legumes. Such plants can meet their N needs through both biological nitrogen fixation (symbiosis) and native nitrogen in the soil (Ranganathan and Parthasarathi, 2002, Babu *et al*., 2017, Verma, 2016) [40, 12, 55]. Sreenivas *et al*., (2000) [51] studied the integrated effect of application of fertilizer and vermicompost on soil available nitrogen and uptake of ridge gourd. Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 t ha^{-1} vermicompost. Similarly, the uptake of nitrogen, phosphorus, potassium and magnesium by rice plant was highest when fertilizer was applied in combination with vermicompost (Verma *et al*., 2018, Babu *et al*., 2017, Verma, 2016, Jadhav *et al*., 1997) [56-57, 55, 12]. Similarly, Sailaja kumari and Ushakumari (2002) [36] studied the effect of enriched vermicompost with rock phosphate on the yield and uptake of nutrients by cowpea and revealed that enriched vermicompost showed its superiority over other treatments for uptake of major nutrients like N, P, K, S, Ca, and Mg.

Effects of Vermicompost on Soil Biochemical and Microbiological Properties

Regarding the nutrient content of the soil at harvest there were no differences in N-NH_4 +, N-NO_3 - or K_2O_5 between the fertilizing treatments and doses applied. However, the PO_4 - content of the soil was significantly higher in the plots to which vermicompost was added than in the plots that received only inorganic fertilizers or manure. However, this only took place at the high doses applied, whereas there were no differences between the treatments at the normal dose-Glucosidase, protease and alkaline phosphomonoesterase enzyme activity rates were significantly higher in the soil plots amended with vermicompost and manure than in those treated with inorganic fertilizer. Fertilization with vermicompost and manure also favored growth of microorganisms in the soil. Bacterial growth increased significantly after application of the high doses of vermicompost and manure, although fungal growth was not affected. Organic amendments promoted microbial growth, which resulted in a higher soil microbial biomass, although only in the plots treated with manure. The increase in soil microbial biomass was due exclusively to an increase in Gram-negative bacteria, as shown by the increased concentration of the PLFAs (phospholipids fatty acid) biomarkers for this microbial group. Replacement of 25% of the nutrients provided to the corn plants by vermicompost maintains plant productivity at the same levels than 100% inorganic fertilization. In addition, vermicompost produces significant changes in soil biochemical and microbial properties promoting bacterial growth and increasing enzyme activity. In spite of the fact that the same amounts of N, P and K were provided with the three types of fertilizers at each dose, vermicompost amended plots exhibited higher phosphatase and phosphate levels, and the P content of the plants was higher than in soils with inorganic fertilization. The results presented here confirm that there is a large variation in vermicompost effects depending on the plant genotype. Therefore, within a given crop certain genotypes or varieties may be more suitable for organic or combined inorganic-organic cropping systems, than others.

Effect of Vermicompost on Soil Physical, Chemical and Biological properties

Studies on vermicompost indicate that it increases macro pore space ranging from 50 to 500 µm, resulting in improved air-water relationship in the soil which favorably affects plant growth (Verma *et al*., 2018, Verma, 2016, Marinari *et al*., 2000) [56-57, 55]. The application of organic matter including vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al*., 1999) [37]. It also reduces the proportion of water-soluble chemical species, which cause possible environmental contamination (Mitchell and Edwards, 1997) [38]. A field experiment was conducted by Kannan *et al*., (2005) [31], with tomato to study the influence of different organic N sources *viz*, FYM, Vermicompost and compost with bioferilizers on the soil physical properties, nutrient availability and biological properties reported application of vermicompost (75% N) with azospirillum was found superior in influencing the soil physical, chemical and biological environment such as bulk density, soil porocity, water holding capacity, organic carbon, available nitrogen, beneficial bacterial and fungal population over the other treatments.

Advantages of Vermicompost

Many researchers conducted various experiments on vermicompost to examine its chemical and biological aspect. A few scientist coated advantages of vermicompost which is describe below.

- It is rich in all essential plant nutrients and contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
- It is free flowing, easy to apply, handle and store and does not have bad odour.
- It improves soil structure, texture, aeration, and water holding capacity and prevents soil erosion.
- It is rich in beneficial micro flora such as a fixers, P-solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
- It contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers and enhances the decomposition of organic matter in soil.
- It is free from pathogens, toxic elements, weed seeds etc. and minimizes the incidence of pest and diseases.

Conclusions

Vermicompost can be described as a complex mixture of earthworm faeces, humified organic matter and microorganisms, which when added to the soil or plant growing media, increases germination, growth, flowering, fruit production and accelerates the development of a wide range of plant species. The enhanced plant growth may be attributed to various direct and indirect mechanisms, including biologically mediated mechanisms such as the supply of plant-growth regulating substances, and improvements in soil biological functions. Use of this type of organic fertilizer therefore has great potential; however some recent studies raise serious doubts about the general applicability of these results and propose a more complex model of action for these types of effects. Stimulation of plant growth may depend mainly on the biological characteristics of vermicompost, the plant species used, and the cultivation conditions. Extensive research on inorganic fertilization and plant breeding, carried out within the framework of conventional agriculture, has allowed agricultural producers to fine-tune nutrient inputs and plant needs in order to maximize yields. However, such detailed knowledge has not yet been attained as regards the interactions between plants and organic fertilizers in sustainable agriculture. Given the complex and variable composition of vermicompost in comparison with inorganic fertilizers and the myriad of effects that it can have on soil functioning, a clear and objective concept of vermicompost is required, and the complex interactions between vermicompost-soil-plant must be unraveled in order to maintain consumer confidence in this type of organic fertilizer.

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