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Effect of vermicompost on soil quality and crop productivity

[1]Akram Gazi, [1]Ani Maity, [1]Nabanita Khatua, [1]Sudip Sengupta, [1]Suprabuddha Kundu and [1]Tanmoy Sarkar

[1]School of Agriculture, Swami Vivekananda University, Barrackpore, West Bengal, India

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Corresponding Author: Sudip Sengupta

Abstract

The sustainable intensification of agriculture necessitates innovative approaches to enhance soil quality and crop productivity while minimizing the negative environmental impacts of conventional farming practices. Vermicompost, a nutrient-rich organic material produced through the decomposition of organic waste by earthworms, has gained significant attention as a potential solution to address these challenges. Vermicompost is rich in essential plant nutrients, organic matter, beneficial microorganisms, and growth-promoting substances. Its application to soils has been demonstrated to ameliorate various soil properties, including improved soil structure, increased water-holding capacity, enhanced nutrient retention, and increased microbial activity. These improvements contribute to overall soil health and fertility, leading to enhanced plant growth and productivity. The introduction of vermicompost into agricultural systems has shown several positive effects on crop growth and development. These effects encompass increased germination rates, improved root development, enhanced nutrient uptake, and heightened resistance to pests and diseases. The benefits of vermicompost application extend beyond the improvement of soil physical and chemical properties. By recycling organic waste materials, vermicomposting contributes to waste reduction and environmental sustainability. By bridging the gap between waste management and agricultural productivity, vermicompost emerges as a valuable tool in promoting both environmental conservation and food security.

Keywords: Vermicompost, sustainability, soil fertility, productivity, waste management

1. Introduction

The use of chemical fertilizers has increased tremendously from green revolution leading to heavy dependence on chemical fertilizer in conventional agricultural system. The application of chemical fertilizers, no doubt has increased the crop productivity many folds, but their continuous and imbalanced application has also produced detrimental effects on soil health due to which crop yields have become stagnated in past few decades. The long term fertilizer experimental studies indicated that continuous sole application of chemical fertilizer in imbalanced manner produce detrimental effects on soil physical, chemical and biological properties further, inducing secondary and micronutrient deficiencies in soil, nutrient imbalance in soil and plants, environmental hazards and decrease in total factor productivity. Microbial Population in soil also severely affected due to imbalanced fertilizer application. Moreover, excessive fertilizer applications are also contaminating surface and underground water bodies especially by nitrate leaching (Pimentel 1996) [92] and causing detrimental effects on environment, which in turn is causing serious hazards to human and animal health. Therefore, in present context, there is dire need to follow climate resilient integrated crop management modules so that soil health and crop productivity could be sustained for longer time. In above scenario, one of the possible options to reduce the use of chemical fertilizer could be recycling of organic wastes (Kumar *et al*. 2018) [67].

Increasing population pressure has forced many countries to use inorganic fertilizers, pesticides and ground water to increase crop productivity in order to meet continuously increasing food demand. The prolonged and excessive use of inorganic fertilizers, pesticides and ground water in crop production exerted severe human and soil health hazards along with environmental pollution. Considering these human and soil health hazards, farmers in developed and underdeveloped countries are encouraged to convert their farms into organic farms (Rahman and Barmon 2019) [96].

The overuse of synthetic fertilizers has a great impact on the environment and the cost of these fertilizers has increased over the years. The need of the hour is to raise the crops by organic farming that will reduce the costs and will decrease the impact on the environment. In addition, organic farming will also reduce the additional burden of environmental pollution that is caused while manufacturing these synthetic fertilizers at the source (Rathier and Frink 1989) [97].

Thus, inclusion of vermicompost organic manure in crop production is a better alternative for improving soil health; crop productivity and quality as it exert a significant positive influence on soil properties and microbial population.

2. Vermicompost and vermicomposting

Vermicomposting is the practice of utilizing earthworms to convert organic waste into compost that is rich in nutrients. Earthworms that live in the soil interact. It consumes dead organic litter and releases it as castings, which is a crucial function in agriculture. By releasing minerals in forms that are simple for plants to absorb, earthworms hasten the breakdown of organic debris and plant litter while increasing soil fertility (Curry 1987) [36]. The majority of minerals found in vermicompost, including nitrates, phosphates, exchangeable calcium, and soluble potassium, are available to plants (Edwards 1998; Orozco 1996) [40, 89]. Earthworms affect the physical, chemical, and biological aspects of organic materials and soil for plant development and nutrient uptake through their feeding, burrowing, and casting behaviors. Vermicompost supplies numerous microsites for because of its substantial surface area.

Vermicompost is a finely divided, peat-like material that has high porosity, good aeration, drainage, water holding capacity, microbial activity, excellent nutrient status, and buffering capacity. These physical and chemical characteristics are necessary for soil fertility and plant growth (Fig 1).

Vermicompost significantly stimulates the growth of a wide range of plant species including several horticultural crops such as tomato (Atiyeh *et al*. 1999; Atiyeh *et al*. 2000a; Atiyeh *et al*. 2000b; Atiyeh *et al*. 2001; Hashemimajd *et al*. 2004; Gutiérrez-Miceli *et al*. 2007) [22, 16, 18, 19, 20, 120-121], pepper (Arancon *et al*. 2004a, Arancon *et al*. 2005), garlic (Argüello *et al*. 2006) [13, 8, 122], Aubergine (Gajalakshmi and Abbasi 2004) [123], strawberry (Arancon *et al*. 2004b) [123], sweet corn (Lazcano *et al*. 2011) [124] and green gram (Karmegam *et al*. 1999) [65]. Vermicompost has also been found to have positive effects on some aromatic and medicinal plants (Anwar *et al*. 2005; Prabha *et al*. 2007) [125, 126], cereals such as sorghum and rice (Bhattacharjee *et al*. 2001; Reddy and Ohkura 2004; Sunil *et al*. 2005) [127, 128], fruit crops such as banana and papaya (Cabanas-Echevarria *et al*. 2005; Acevedo and Pire 2004) [129, 130], and ornamentals such as geranium (Chand *et al*. 2007) [131], Marigolds (Atiyeh *et al*. 2002) [17], petunia (Arancon *et al*. 2008) [6], chrysanthemum and poinsettia. Positive effects of vermicompost have also been observed in forestry species such as acacia, eucalyptus and pine tree (Donald and Visser 1989) [132].

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) [133], sorghum (Gutiérrez-Miceli *et al*. 2008) [52], and strawberries (Singh *et al*. 2010) [134]. Vermicompost has beneficial impacts for a variety of plant species, including pine trees, petunias (Arancon *et al*. 2008) [6], tomato plants (Atiyeh *et al*. 2000b) [18], green gram (Karmegam *et al*. 1999) [65], and tomato plants (Atiyeh *et al*. 2000b) [18]. Vermicompost has a favorable impact on vegetative growth as well, encouraging the formation of shoots and roots (Edwards *et al*. 2004) [43]. According to Lazcano *et al*. (2013) [23], these modifications to seedling morphology include increased leaf area and root branching. Vermicompost has also been demonstrated to promote plant flowering, resulting in an increase in the quantity and biomass of the flowers produced (Atiyeh *et al*. 2002; Arancon *et al*. 2008) [17, 6], as well as an increase in fruit production (Atiyeh *et al*. 2000b; Arancon *et al*. 2004a, 2004b; Singh *et al*. 2008) [18, 13, 123, 135]. Vermicompost may improve the nutritional value of some vegetable crops, including tomatoes (Gutierrez-Miceli *et al*. 2007) [122], Chinese cabbage (Wang *et al*. 2010) [136], spinach (Peyvast *et al*. 2008) [90], strawberries (Singh *et al*. 2008) [135], lettuce (Coria-Cayupán *et al*. 2009) [137], and sweet corn (Lazcano *et al*. 2011) [124].

Nevertheless, there is substantial empirical evidence that vermicompost has beneficial impacts on plant development and yield but that these advantages are not universal or consistent and that the degree of the effects varies widely. In fact, according to some studies (Roberts *et al*. 2007) [138], vermicompost may stunt plant growth or even result in plant mortality. The physical, chemical, and biological characteristics of vermicompost, which differ greatly depending on the original feedstock, the earthworm species used, the production process, and the age of vermicompost, may also affect the variability in the effects of vermicompost (Rodda *et al*. 2006, Roberts *et al*. 2007; Warman and AngLopez 2010) [139, 138].

Recent studies have shown that organic fertilizers like vermicomposting improve soil organic matter, microbial biomass, and activity. Vermicomposts may boost plant development by increasing beneficial enzyme activity and microbe populations, as well as by containing physiologically active chemicals that influence plant growth, such as plant growth regulators or plant hormones and humic acids. Vermicompost was shown to have a greater level of dehydrogenase activity than commercial medium, which is typically used to measure the respiratory activity of microbial communities. Soil dehydrogenase activity in vermicompost-treated plots was significantly lower at the time of transplantation. This might be due to the exotic microflora being inhibited by ‘foreign’ soil microbes from vermicomposts. Microbes have begun to compete as a result of this phenomenon.

As a bio-inoculant, vermicompost helps introduce helpful microorganisms to the plant’s rhizosphere. This activates legume nitrogen fixation enzymes. Nitrogen availability will be increased in the soil as a result of the enhanced nitrogen status of the soil. Vermicompost might potentially be used to boost the availability of phosphate due to the increased phosphatase activity. An organic manure (farmyard manure, vermicompost, neem cake and ash) and bio fertilizer mixture increased the activities of dehydrogenase, acid phosphatase and glycosylase in soil. Glycosidase and phosphatase, as hydrolytic enzymes involved in the C and P cycles, are critical for monitoring the stability of organic materials. It is hypothesized that certain biochemical properties in the soil may be indicators of soil quality. Treatment of vermicompost in large amounts in the field suppresses many plant diseases by reducing parasite fungi including Pythium, Rhizoctonia, and Verticillium.

Vermicomposts reduce plant parasitic nematodes while increasing the activity of vesicular arbuscular mycorrhizae. According to data, *Eisenia fetida* reduced plant-parasitic nematode populations by more than 60% in soil cultures, by 98.8% in casts, and by 50% in cultures utilizing alfalfa root tissue. Eight lumbricid species, on the other hand, reduced the amount of plant parasitic nematodes.

Due to their capacity to solubilize insoluble phosphorus and decompose agricultural wastes, which release plant nutrients, soil organisms play a significant role in enhancing soil fertility and crop productivity. Vermicomposting reduces the C: N ratio and preserves more N than the conventional techniques of making composts and it turns household garbage into compost in less than 30 days (Gandhi 1997) [48]. The great quantity and high quality of nutrients found in vermicomposts can be attributed to the process's rapid mineralization of organic waste, breakdown of polysaccharides and higher rate of humification. Vermicompost increases nutrient uptake by plants and offers all nutrients in easily accessible form. Studies on the combined impact of fertilizer application and Vermicompost application on soil accessible nitrogen and uptake of ridge gourd show that soil available N increased significantly with increasing levels of Vermicompost. The maximum N uptake was achieved at 10 ton /ha of Vermicompost and 50% of the recommended fertilizer rate (Sreenivas 2000) [107]. In different agroecosystems, particularly under jhum, where the use of agrochemicals is minimal, earthworms play a significant role in the recycling of nitrogen. When fertilizer was sprayed along with vermicompost, the uptake of nitrogen, phosphorus, potassium and magnesium by the rice plant was maximum (Jadhav 1997) [56]. Significant amounts of nutrients are rejected by earthworms in these casts. In the urine that the worm excretes, nitrogen is primarily expelled as ammonium (Lee 1985) [70]. After adding Vermicompost to the soil, the amount of accessible p and k as well as the amount of soil nitrogen dramatically increased. Earthworms accelerated the decomposition of trash, as evident by a drop in the C: N ratio. However compared to compost made without worms, the plant interest content of Vermicompost was not significantly higher (Bansal 2000) [109].

3. Effect of organic vermicompost on microbes and plants

In a study the medicinal plant and *Orgaphis paniculata* was grown on vermicomposted coirpith and coirpith composted with microbes. The findings suggested that vermicomposted coirpith could be useful for reclaiming industrial site soils in a small nursery (Vijaya *et al*. 2008) [116]. When compared to artificial fertilizer, increased quantities of composted manure significantly enhanced the proportion of essential oil fresh matter and dry matter in marjoram plants (Edris *et al*. 2003) [39]. An enhanced German chamomile called "Goral" has its morphological traits and essential oil content assessed in an Iranian experiment using various vermicomposting and irrigation levels. The outcomes should that the application of vermicompost greatly increased plant height, early flowering, and flower dry weight etc. In 10% vermicompost the maximum essential oil output was found (Azizi *et al*. 2008) [25].

4. Effect of Vermicompost on growth and yield of crop

Vermicomposts can routinely have favourable effects on plant germination, growth and yield as many tests have shown (Table 1). They also claimed that when cultivated in vermicomposts as opposed to commercial planting media, some ornamental plants including chrysanthemum and petunias blossomed earlier. Pig waste vermicomposts have been shown to stimulate soybean growth. Particularly in terms of increased root lengths lateral root numbers and internode length of seedlings (Bansal Sudha 2000) [109]. After being transplanted into the field, cabbages grown in compressed blocks manufactured from pig waste vermicompost were larger and more mature at harvest than those grown in commercial blocking material. The enhanced microbial activity encouraged by earthworms is responsible for the generation of plant growth hormones such as indole acetic acid, gibberellins and cytokinins as well as other PGRs like humates, which likely a direct impact on plant development and yields. The existence of plant growth inhibiting chemicals in the form of hormones found in aqueous extracts from Vermicompost as well as humic acids acquired in base extracts from vermicomposts, has been shown through bioassays in the laboratory.

5. Effect of vermicompost on biochemical constituents in fruits

After 60 days the chilli plant's fruits were harvested and different biochemical components were examined. The treatment triple 17 complex + vermicompost had the highest levels of the biochemical components starch, carbohydrates, reducing starch, protein, calcium, magnesium and ascorbic acid, total phenol etc. The lowest levels were found in the control. According to a study by vermicompost application resulted in the highest carbohydrates content (Kurumkar 2003) [69]. The results of the current experiment showed that the treatment boosted the biochemical components of the chilli plants. This suggests that improving the nutrient composition of chilli fruit requires the use of both organic and inorganic fertilizer such as vermicompost or organic manures.

6. Effect of vermicompost on soil properties

The amount of organic carbon increased the pH reduced bulk density, increased water retention capacity and soil porosities. Vermicompost treatment results in enhanced microbial populations and dehydrogenase activity in soils (Suthar Surindra 2009) [140]. Vermicompost, according to studies, expands soil's macropore space by 50 to 500 micrometers, improving the soil's air-water balance, which benefits plant growth. Other properties of worm treated soils include improvements in soil consistency with a parallel rise in porosity, infiltration, and soil water retention. While consuming organic elements, earthworms produced gelatinous substances that cover and maintain soil aggregates. Earthworms create and stabilize soil aggregates through complicated and poorly understood mechanisms. Casts made by earthworms are typically more water-resistant than mixtures made of specific soils. Although stability appeared to increase over time following deposition, freshly produced casts appeared to be less stable than other soil aggregates (Sengupta *et al*. 2022) [100].

7. Effect of Vermicompost on soil biological properties

Vermicomposts offer several exceptional qualities. They contain a variety of bacteria, actinomycetes, fungus, and bacteria that break down cellulose. Additionally, earthworm castings, which were produced following the digestion of sludge, were abundant in microorganisms, particularly bacteria. A very large body of research has shown that microorganisms, such as bacteria, fungi, yeast, actinomycetes, and algae, are capable of producing significant amounts of plant growth hormones and plant growth regulators (PGRs), including auxins, gibberellins, cytokinins, ethylene, and abscisic acid. Numerous microbes that are frequently found in the rhizospheres of plants are capable of producing these compounds that control plant development. For example, of 50 bacterial isolates collected from the rhizosphere of different plants, 86% were capable of producing auxins, 58% gibbereline, and 90% kinetic-like substances (Azizi *et al*. 2008) [25].

8. Effect of Vermicompost on soil fertility

Darwin (1881) was the first to draw attention to the function of earthworms in the breakdown of organic detritus on the soil surface and in the soil rotation process. Following that, it has taken over a century for people to recognize its significant contribution to reducing organic pollutants, improve soil fertility and producing topsoil in underdeveloped areas. Since 1978, there has been a rise in interest in potential techniques for employing earthworms to digest organic wastes and create useful soil additives. Earthworms have evolved to dwell on decaying organic wastes and may break it down into fine particle materials that are rich in readily available nutrients and have the potential to be added to soil to increase soil productivity.

Applications of vermicompost improve soil Fertility by adding vitamins, enzymes, hormones, and micro- and macronutrients. They also control the physico-chemical characteristics of the soil, which helps plants grow (Sinha *et al*. 2009; Hazra 2016) [106, 53]. Products made from vermicompost provide vital nutrients in a form that plants can readily absorb (Pathma and Sakthivel 2012) [59]. The primary cause of this is the mesolithic composting phase that vermicompost undergoes following thermolithic composting, which causes further disintegration. Vermicompost (Erdal *et al*. 2000) [44], which produces a substance rich in humic acids, aids in the development of roots and increases plant biomass (Delibacak and Ongun 2016) [37].

Vermicomposting can raise the soil's nitrogen content by 42%, phosphorus by 29%, and potassium by 57%. The application of vermicompost at 7.5 t/ha improved the concentration of organic carbon (0.39%) and boosted soil fertility. After the harvest of forage sorghum, the soil had 219 kg/ha of accessible nitrogen (Sharma and Agrawal 2003) [101]. According to Kumar *et al*. (2005) [66], vermicompost (5 t/ha), farmyard manure (5 t/ha), and inorganic fertilizers (nitrogen @ 40 kg/ha + phosphorus @ 20 kg/ha) were the fertilizer applications that resulted in the greatest residue build-up of organic carbon and available nitrogen, phosphorus, and potassium in the soil. Applying vermicompost at a rate of 3 t/ha to a chickpea crop increased nitrogen and phosphorus content and bacterial count in the soil, dry fodder yield of succeeding maize, and total nitrogen and phosphorus, according to Jat and Ahlawat (2006) [58]. Suhane (2007) [111] found that vermicompost has more than 95% exchangeable potassium. Application of vermicompost considerably enhanced the chemical characteristics of the soil, including pH, electrical conductivity, organic matter, and nutrient status, which enhanced plant growth and yield (Lim *et al*. 2015) [72].

9. Effect of Vermicompost on Soil Water Holding Capacity

Environmental disturbances brought on by the overuse of natural resources have pushed people to reconsider ways to save water. The hydrologic cycle has been considered to be seriously threatened by the global climate change. The ultimate goal of technologies like rainwater collection, watershed management, etc. is to maintain the water cycle, which results in increasing water resources. All terrestrial ecosystems are severely constrained by water because all vegetation needs vast amounts of water to develop and produce fruit (Flankenmark 1989; Pimentel *et al*. 1995) [45, 91]. Therefore, it is crucial to "save water" in whatever best practices have been implemented. Vermitechnology (VT) is one of the technologies that have gained popularity recently. In addition to utilizing misplaced resources, vermicompost (VC) of available agricultural residues (Kale *et al*. 1987) [61] and industrial wastes (Munnoli and Bhosle 2007, Suthar 2009, Suthar and Singh 2008, Pagaria and Totwat 2007) [78, 140, 141] also enriches the soil fertility with increased water-holding capacity that aids in maintaining the hydrologic cycle. In drier conditions, the application of VC supplies water to the root zone depth (Munnoli 2007) [78]. There are reports of studies on soil and cast aggregation (Munnoli *et al*. 2000, Munnoli and Bhosle 2009; Edwards and Lofty 1977; Singh 1997) [79, 103, 142, 143, 103] but no experimental study focused on the water-holding capacity of vermicomposts. The cementation of aggregates by organic, inorganic, or microbiological films determines the stability of the aggregates. To the soil plant system, the area surrounded by and within the soil aggregates is of highest importance. The passage of water, the diffusion of gases, and the expansion and development of roots in the soil are all governed by the stability and toughness of these pores. The degree of aggregation affects the pore structure's stability and endurance.

More hygroscopic water and capillary water, which is the water between the casts, will be held in an aggregate correlation with higher geotechnical qualities that improves the interpore gaps and aeration. Vermicast provides spectacular results in cases of water scarcity by releasing the water trapped in the pore spaces. The cast has the capacity to absorb moisture, especially at night, while also preventing moisture evaporation when applied to soil surfaces (Bhawalkar & Bhawalkar 1992) [29].

10. Effect of Vermicompost on soil structure

An experiment was conducted in a split plot with three replications at Sari Agricultural Sciences and Natural Resources University to determine the impact of vermicompost on the physical and chemical qualities of soil. Bulk density, particle density, total porosity, water holding capacity, field capacity, permanent wilting point, accessible water capacity, pH, organic carbon, and electrical conductivity were among the physical and chemical characteristics of soil. According to the study's findings, applying these treatments to soil increased its total porosity, ability to hold water, field capacity, and permanent wilting point, capacity for available water, organic carbon electrical conductivity, and decreased bulk density, particle density, and pH when compared to the control. Contrarily, aside from FC, PWP, AWC, pH, OC, and EC, years of fertilizer usage had no appreciable impact on the physical parameters of the soil. Only particle density and field capacity significantly affected the relationship between years of fertilizer consumption.

Composting enhances soil physical qualities by lowering bulk density and raising soil water holding capacity, according to the findings of various long-term researches. Additionally, compost greatly boosts soil organic carbon and some plant nutrients when compared to mineral fertilizers (Garca-Gil 2000; Bulluck 2002; Nardi 2004) [49, 31, 86]. The use of organic amendments, such as conventional thermophilic composts, has generally been acknowledged as an efficient way to enhance soil aggregation, structure, and fertility, increase microbial diversity and populations, enhance soil moisture-holding capacity, enhance soil cation exchange capacity (CEC), and boost crop yields (Zink and Allen 1998) [120]. Most nutrients in vermicompost are in forms that plants may use, like nitrates, phosphates, exchangeable calcium, and soluble potassium (Orozco 1996) [89]. Vermicompost has been shown to have high levels of total and available nitrogen, phosphorus, potassium (NPK), and micronutrients, as well as microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan 1999; Chaoui 2003) [88, 48, 35]. With proper management, continuous and adequate use of vermicompost can increase soil organic carbon, soil water retention and transmission, and improve other physical properties of soil like bulk density, penetration resistance, and aggregation as well as beneficial effect on the growth of a variety of plants (Atiyeh 2002) [17]. Vasanthi and Kumarasamy (1999) [114] discovered a notable rise in CEC of the soil treated with vermicompost and NPK. After ragi and cowpea harvest, the pH of the soils treated with enriched compost made from industrial wastes decreased (Srikanth 2000) [108]. Researchers Vasanthi and Kumarasamy (1999) [114] and Srikanth (2000) [108] used several enriched composts, including vermicompost. After the harvest of rice, ragi, and cowpea, the soils treated with enriched compost made from various organic wastes, FYM, vermicompost, and vermicompost with NPK showed increased availability of NPK (Vasanthi and Kumarasamy 1999; Srikanth 2000; Sailajakumari and Ushakumari 2002; Chaoui 2003) [108, 114, 97, 35] have been shown to have increased OC content in the soil. According to Chaoui (2003) [35], manure treatment is recognized to promote and increase stable soil structure, bacterial and fungal population, and biological activity. It has been demonstrated that the increased pore volume in soils modified with compost and earthworm casts increases the availability of nutrients and water to soil microbes (Scott 1996) [98]. Composted materials also alter the chemical and physical properties of the soil, which can be seen in increases in microbial biomass and activity changes in the activity of soil enzymes (Garcia-Gil 2000; Ros 2006) [49, 96], and changes in the composition of the microbial community (Ros 2006) [96]. The main determinants of generated runoff in arid and semiarid regions, in addition to local precipitation parameters, include soil surface conditions such soil properties, plant cover, and terrain. According to Arsham (2008) [15], the soil moisture in these places plays a significant role as well as runoff. The buffering that vermicompost provides during plant element adsorption is one of the most significant benefits (Bawman and Rink 1991) [30]. Vermicompost improves bulk and real density (Mirzaei 2009) [76], porosity (Matos and Arrunda 2003) [75], aggregate stability and soil structure, as well as the rate of water penetration and aeration in the soil (Mahdavi 2007) [73].

Table 1: Effect of vermicompost on crop production

Sl.no.	Crop	Treatment	Effect on the Crop	Area of Study	Reference
1.	Cauliflower (*Brassica oleracea var. botrytis* L.)	Vermicompost (5 t ha^{-1}) +135-60-135-21-3-1.5 kg ha^{-1} of N-P-K-S-Zn-B	Increase Crop Productivity	Sylhet, Bangladesh	Ghosh and Hasan (1997) [51]
2.	Spinach (*Spinacia oleracea*)	Vermicompost @4 t ha^{-1}	Increase Crop Productivity	Lucknow, Uttar Pradesh	Ansari (2008) [5]
3.	Turnip (*Brassica campestris*)	Vermicompost @4 t ha^{-1}	Increase Crop Productivity	Lucknow, Uttar Pradesh	Ansari (2008) [5]
4.	Cucumber (*Cucumis sativus* L.)	Vermicompost 6 t ha^{-1}+P 25 kg ha^{-1}+ Zn 1.5 kg ha^{-1}	Increase stem girth and branch number	Narayanganj, Bangladesh	Hossain *et al*. (2020) [54]
5.	Mustard (*Brassica juncea*)	Vermicompost 5 t ha^{-1}	Increase seed and stover yield	Udaipur, Rajasthan	Kansotia *et al*. (2013) and Singh *et al*. (2014) [69, 105]
6.	Potato (*Solanum tuberosum*)	Vermicompost @6 t ha^{-1}	Increase Crop Productivity	Lucknow, Uttar Pradesh	Ansari (2008) [5]
7.	Tomato (*solanum Lycopersicum*)	Vermicompost 2.8 t ha^{-1} and Nitrogen 100 kg ha^{-1}	Increase Crop Productivity	Sofi district, Harari, Ethiopia	Benti *et al*., (2021) [27]
8.	Taramira (*Eruca sativa*)	Vermicompost 3.0 t ha^{-1}	Increase crop dry matter, primary and secondary branches/ plant, number of siliquae/ plant, seeds/ siliqua and test weight	Jobner, Jaipur district, Rajasthan	Chand *et al*. (2002) and Premi *et al*. (2004) [33, 27]
9.	Groundnut (*Arachis hypogaea*)	6 t ha^{-1} vermicompost and 4 t ha^{-1} poultry manure	Increase number of pod per plant, number of seed per plant, Seed per pod, kernel weight, yield (q/ha), oil percentage, protein percentage and oil yield (kg/ha)	Chitrakoot, Satna Madhya Pradesh	Bhatt *et al*., (2013) [28]
10.	Green gram (*Vigna radiata*)	Vermicompost 6 t ha^{-1} + 3% Panchagavya (30, 45 DAS)	Increase Crop Productivity	Prayagraj, Uttar Pradesh	Jadhav *et al*. (2011) [57]

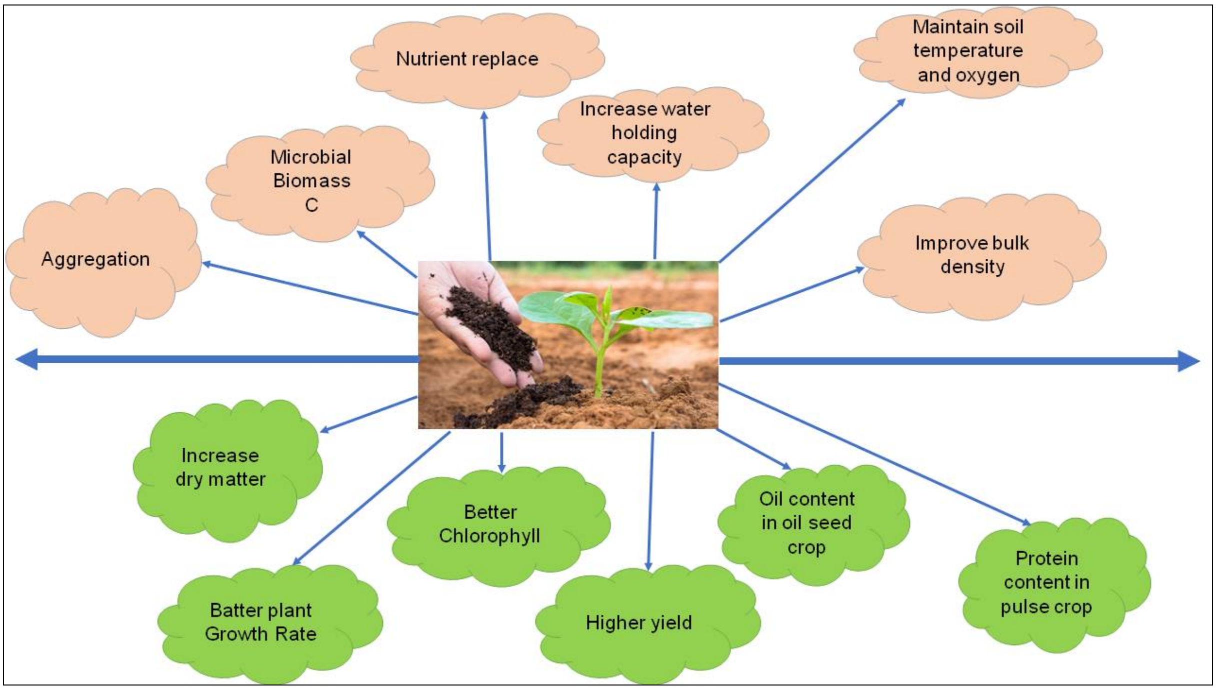

Fig 1: Effect of vermicompost on soil and plant growth

11. Conclusion

In conclusion, the impact of vermicompost on soil quality and crop productivity cannot be overstated. Throughout this discussion, we have explored the multifaceted benefits of incorporating vermicompost into agricultural practices. From improving soil structure and fertility to enhancing nutrient availability and microbial diversity, vermicompost has proven to be a valuable tool for sustainable farming. One of the most significant advantages of vermicompost is its ability to foster a harmonious relationship between the soil, plants, and beneficial microorganisms. This holistic approach not only promotes healthy crop growth but also contributes to the long-term health of the ecosystem. Furthermore, the use of vermicompost aligns with sustainable and environmentally friendly agricultural practices. It reduces the reliance on synthetic fertilizers and chemical pesticides, thus mitigating the harmful effects of conventional farming on the environment. Crop productivity benefits from vermicompost are evident in increased yields, improved crop quality, and reduced susceptibility to diseases and pests. Moreover, the long-term benefits of enhanced soil structure and nutrient retention make vermicompost an investment in the future of agriculture. As we move forward in the quest for sustainable food production, vermicompost emerges as a valuable ally. Its positive effects on soil quality and crop productivity offer a promising avenue for meeting the global challenge of feeding a growing population while preserving our planet's health. Embracing the use of vermicompost in agriculture can lead us towards a more resilient and sustainable farming future.

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