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Effects of Vermicompost on Sustainable Agriculture Under Different Growing Conditions

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Abstract

Sustainable agriculture aims to providing a healthy food source and a habitable environment for future generations, plays the fundamental role in agriculture, ensuring both food security and environmental sustainability. Organic fertilizers are frequently utilized in achieving these objectives in crops production. Vermicompost is a natural and high-valued organic fertilizer used in sustainable agricultural practices, resulting of organic waste breakdown by earthworms. The organic matter digested by worms forms vermicompost, containing beneficial nutrients for the soil and plants. This fertilizer enhances soil health and promotes plant growth. However, the growing environments of plants also hold significance in terms of sustainability. This study, focusing on the impact of vermicompost on plants grown under different conditions such as field, greenhouse, and soilless environments, emphasizes the role of vermicompost in improving soil health, reducing chemical fertilizer use, and serving as a significant component of sustainable agriculture. According to information gathered from literature studies, vermicompost contributes to plant yield and quality, predominantly in greenhouse conditions. It has been observed that vermicompost can serve as an alternative to chemical fertilizers or effectively reduce their usage and enhance sustainability, deciding optimal doses.

Keywords: Field, greenhouse, soilless agriculture, sustainable agriculture, vermicompost

Vermikompostun Farklı Yetiştirme Koşullarında Sürdürülebilir Tarım Üzerine Etkisi

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Öz

Sürdürülebilir tarım, gelecek nesiller için sağlıklı bir gıda kaynağı ve yaşanabilir bir çevre sağlama amacıyla tarımda temel bir rol oynamaktadır. Organik gübreler, bu hedeflere ulaşmada sıkça kullanılan araçlardandır. Vermikompost, toprak solucanları tarafından organik atıkların ayrıştırılması

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sonucunda elde edilen doğal ve yüksek değerli bir organik gübredir. Solucanların sindirdiği organik madde toprak ve bitkiler için faydalı besinleri içeren vermikompostu oluşturur. Bu gübre, toprak sağlığını iyileştirir ve bitki büyümesini teşvik eder. Ancak bitkilerin büyüdüğü çevrelerin de sürdürülebilirlik açısından önemi bulunmaktadır. Bu çalışma, farklı koşullar altında yetiştirilen bitkiler üzerinde vermikompostun etkisine odaklanmakta; tarla, sera ve topraksız ortamlarda vermikompostun toprak sağlığını iyileştirme, kimyasal gübre kullanımını azaltma ve sürdürülebilir tarımın önemli bir bileşeni olarak rolünü vurgulamaktadır. Literatür çalışmalarından elde edilen bilgilere göre, vermikompost farklı yetiştirme koşullarında bitki verimi ve kalitesine katkı sağlamaktadır. Verimli dozajların belirlenmesiyle, vermikompostun kimyasal gübrelere alternatif olarak kullanılabildiği ve onların kullanımını etkili bir şekilde azaltabildiği gözlemlenmiştir.

Anahtar Kelimeler: Sera, sürdürülebilir tarım, tarla, topraksız tarım, vermikompost

1. Introduction

The utilization of chemical fertilizers significantly rises all over the world approximately 60 years ago due to increasing global population, resulting an increasing demand for nutrients. Over time, it became apparent that these fertilizers had harmful effects for both on the environment and human health (Throat and More, 2022; Türkmen et al., 2021). Therefore, there has been a growing interest in organic fertilizers, leading to the using of fertilizers such as food waste, green manure, animal manure, and vermicompost generated through composting methods.

Sustainability is a critical concept that takes part at the center of modern agriculture and food production. Sustainable agriculture aims to balance agronomic, environmental, economic, and social aspects. To hand down a healthy food source and a habitable environment for future generations, agricultural practices and food production need to be sustainable (Turhan, 2005).

Vermicompost has gained substantial attention in sustainable agriculture due to being an organic fertilizer, nature and its non-hazardous impact on soil pollution (Dayar, 2019). As a reliable, economical, and environmentally friendly resource, vermicompost (worm castings) represents an effective fertilizer that positively contributes to sustainable agricultural crops (Kayabaşı and Yılmaz, 2021). Examining the potential effects of vermicompost on seed germination, plant growth, and productivity is a crucial step toward sustainable agriculture and food production. This article presents studies concerning the impact of vermicompost on sustainable agricultural crops under field, greenhouse, and soilless conditions.

2. Sustainable Agriculture

Sustainable agriculture is a sort of organic farming aimed at increasing yield, maintaining soil health, reducing the use of chemical fertilizers and pesticides, effectively conserving water resources, preventing environmental pollution and eliminating harmful effects on human health (TOB, 2021a; TOB, 2021b) (Figure 1). Particularly, soil health and organic matter content are crucial for ensuring sustainability in agricultural production. Organic matter has positive effects on soil physical, chemical, and biological properties, high water retention capacity and cation exchange capacity (Xu and Mou, 2017). On the other hand, it's known that the use of chemical fertilizers is harmful to both the environment and health (Thorat and More, 2022). For these reasons, the use of organic soil regulators or organic fertilizers, which positively affect yield and quality in consumed foods, is essential for sustainability. While there are many fertilizers obtained from plant and animal waste, vermicompost has been frequently used lately due to its impact on soil regulating and plant growth. Numerous studies have highlighted its contribution to improving plant yield and quality, considering it an important tool for sustainable agriculture (Arancon et al., 2003; Jahan et al., 2014; Rahman et al., 2018; Spheia et al., 2020).

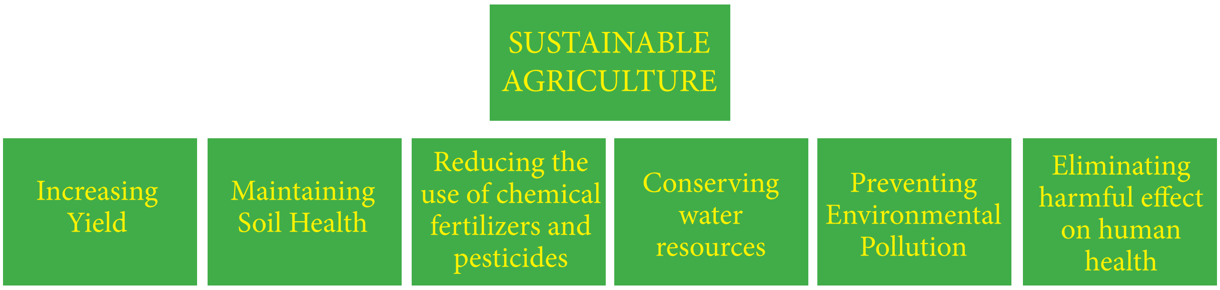

Figure 1. Sustainable Agriculture Purposes

3. Vermicompost

In soil, one can typically find bacteria, fungi, insects, and earthworms. The quantities of these organisms in the soil vary depending on factors such as climate, soil pH, structure, water retention capacity, nutrient element content, and organic matter (Demir, 2010). Earthworms secrete a fluid to sustain vital activities underground, facilitate movement, and defend against diseases. The surface of earthworm casts is coated with this fluid, known as the coelomic fluid. Earthworm casts are rich in amino acids, organic carbon and nitrogen, various nutrients, enzymes, humic acid, and fulvic acid. By dissolving in the soil, these casts create an optimal environment to increase microbial diversity and the population of microorganisms in the soil (Tunç, 2021). In short, earthworms, which positively impact soil fertility by decomposing organic waste, enrich the physical properties of soil, humus formation, and organic matter content (Demir, 2010). The decomposition results in the formation of an organic fertilizer called as vermicompost or biohumus (Abacıoğlu, 2020).

Due to the increased activity in the soil structure imparted by vermicompost, beneficial organisms proliferate, facilitating the uptake of nutrients that plants couldn't access otherwise. This contributes to plant development and enhances plant resistance. Its significant improvement of soil's physical, chemical, and biological properties, as well as its characteristics of leaving no waste in the soil, makes it a preferred choice for producers interested in sustainable and organic agriculture (Dayar, 2019). Numerous studies also indicate its role in protecting plants against various abiotic and biotic stresses, enhancing both yield and quality (Peyvast, 2008; Wang et al., 2017; Calderon and Mortley, 2021).

Among thousands of species, only a few earthworm species are used in vermicompost production. These earthworms can grow in nearly all vegetable wastes and produce waste equal to their own weight in a single day. Under suitable conditions, their numbers can double every 40 days. The most commonly used species is Eisenia fetida, known as the Red Californian Earthworm. These earthworms are used in vermicompost production due to both their secretion of coelomic fluid after being fed with manure and their rapid reproduction. The optimal temperature for these earthworms is 20-25°C, with a pH range of 5-9 and a moisture content between 70-85%. Their reproduction rates vary in different facilities and conditions. Vermicompost can be produced using burial systems, continuous flow systems, and box systems (Dayar, 2019; Özen, 2019)

So, how is vermicompost produced? Are earthworms directly used or their waste? There are two phases in vermicompost production. The first is the active phase, where soil biomass is processed. This biomass generally includes animal manure. During this phase, the physical condition and microbial composition of the soil change. The manure they feed on undergoes changes as it passes through the earthworms' digestive system, known as gut-associated processes (GAPs). The second phase is the maturation phase, which involves waste-associated processes. In this phase, earthworms move towards the undigested newly added manure, indirectly facilitating waste breakdown by microbes. Processed and ready-to-use vermicompost is obtained in the opposite direction of movement (Nasiru et al., 2013; Özen, 2019). The duration of the maturation phase depends on how efficiently the active phase proceeds. The efficiency of the active phase is determined by the species of earthworms, their density, and the ratio of applied residue (Dominguez, 2012).

Vermicompost is suitable for use in various cultivation conditions such as field, greenhouse, and soilness system, in solid or liquid forms (Roberts et al., 2007). While both forms are used in field and greenhouse applications, the liquid form is mostly preferred in hydroponic environments. Liquid vermicompost is also referred to as vermicompost tea or vermitea. Each cultivation environment has its unique advantages, and the choice of method varies based on regional conditions, plant type, and sustainability goals.

3.1. Vermicompost's Impact on Sustainable Agriculture Crops: Studies and Findings

Vermicompost has shown positive effects on various plants as a soil regulator. Studies have been conducted on numerous plants such as parsley (Peyvast et al., 2008), tomato (Arancon et al., 2003, 2012), bell peppers (Arancon et al., 2003), lettuce (Arancon et al., 2012), mustard (Srivastava et al., 2011), strawberries (Arancon et al., 2003, 2004), grass (Tognetti et al., 2005), sorghum (Gutierrez-Miceli et al., 2008), petunias (Arancon et al., 2008), cassava (Padmavathiamma et al., 2008), tomato (Haghigi et al., 2016), spinach (Xu and Mou, 2017), watermelon (Göksu and Kuzucu, 2017), cabbage (Tavalı, 2014), cauliflower (Jahan, 2014) and pepper (Aydın and Demirsoy, 2020) (Table 1). Some of these studies were conducted under field conditions, some in greenhouses, and some in soilness environments. It's crucial to determine the appropriate cultivation environments for achieving the highest yield, best quality, and alignment with sustainability goals. Agricultural practices involving soil utilize fields and greenhouses, while soilless practices involve the application of a mixture of water and liquid nutrients. Each agricultural approach has its advantages and disadvantages, and their suitability depends on environmental conditions, plant species, and the specific objectives of the studies conducted. Below is a brief overview of how vermicompost has been utilized under these different conditions and the resultant effects. It is based on that what the variety, growing area, fertilizer doses are and how the fertilizers are used. Some studies including vermicompost treatments and their effects on some crops is shown in Table 1.

Table 1. Some studies including vermicompost treatments and their effects on some crops (VC: Vermicompost, CF: Chemical fertilizer, C: Combined)

Crop	Variety	Growing Area	Fertilizers and fertilizer doses used in some studies	Using Type	The best result in the study	References
Tomato	F1-Troy	Field	1. Control, 2. Farm Fertilizer (2.5 t/da), 3. Farm Fertilizer + CF N:P:K (18:42:16 kg/da) 100% 4. VC (0.5 t/da), 5. VC + CF N:P:K (9:21:8 kg/da) 5%	C and VC	Recommended: VC should have been used with NPK	Türkmen et al., 2020
	BHN 543 F1	Greenhouse	CF: 130-95-95 kg/ha. VCs produced from dairy cow manure, supermarket food wastes and recycled paper wastes were applied at rates of 10 or 20 t/ha	C	Vermicompost. No statistical difference between VC levels	Arancon et al., 2003
	Ranger F1	Greenhouse	VC: 0, 40, 80 g/plant	VC	Recommended: 160 g/plant	Teke et al., 2019

Table 1. continued

Crop	Variety	Growing Area	Fertilizers and fertilizer doses used in some studies	Using Type	The best result in the study	References
Tomato	Grandella	Hydroponic-Greenhouse	CF: 110-250 mg/l N, 60-140 mg/l P_2O_5, 140-280 mg/l K_2O for germinating. VC and (MSWC) municipal solid waste compost are separately used after germination.	C	VC can improve tomato growth physiology when used as one part of the substrate in hydroponic culture Recommended: MSWC:peat:perlite-25:25:50	Haghigi et al., 2016
Pepper	King Arthur	Greenhouse	CF: 80-75-75 kg/ha. VCs produced from dairy cow manure, supermarket food wastes and recycled paper wastes were applied at rates of 10 or 20 t/ha	C	Vermicompost. No statistical difference between VC levels	Arancon et al., 2003
	Pasarella RZ F1	Soilless	Control: Peat and perlite Each treatment (not control) has 5 g compose fertilizer (15-15-15) with transplanting and 7.5 g urea (CF) for 10 L pots Treatment 1: + waste mushroom compost Treatment 2: + waste mushroom compost + seaweed mixture (2500 ppm) Treatment 3: + solid VC Treatment 4: + solid VC + seaweed mixture (2500 ppm) Treatment 5: + Peat Treatment 6: + Peat + seaweed mixture (2500 ppm)	C	Recommended: VC + seaweed	Aydın and Demirsoy, 2020
Water-melon	Crimson Sweet	Field	CF: 7 kg/da N (NH_4NO_3) and 8 kg/da NH_4SO_3 for 15 kg/da N VC: 300 and 600 kg/da	VC	Positive effect	Göksu and Kuzucu, 2017
Cabbage	Brassica oleracea var. Alba Fieldrocket F1	Field	Basic Fertilizer: 6 kg/da N, 3 kg/da P_2O_5 and 6 kg/da K_2O VC: 100, 200, 400, 800 kg/da	C	400 kg/da VC + NPK	Tavalı et al., 2014
Eggplant	S. melongena	Field	VC: 0 t/ha (Control), 2, 4, 6 t/ha Macrophyte based vermicompost.	VC	6 t/ha	Najar et al., 2015
Cauli-flower	Brassica oleracea L. var. botrytis sub. var. cauliflora CV	Field	Total 12 treatment included RDCF (Recommended Chemical Fertilizer), CF and VC	C, CF and VC	100% RDCF and 1.5 t VC per ha	Jahan et al. 2014
Spinach	Spinacia oleracea L.	Greenhouse	Control: without treatment only soil VC: 5% and 10% solid vermicompost and 40 mL liquid VC extract at 0, 14, 21, 28 days after transplanting	VC	Positive effect	Xu and Mou, 2016
Parsley	(Petroselinum crispum Mill.)	Greenhouse	0:100, 10:100, 20 :100 30:100; VC:Soil (v:v)	VC	Recommended: 10:100	Peyvast et al., 2008
Lettuce (Lactuca sativa L.)	var. capitata cv Bombola	Greenhouse	CF: 15 kg/da N, 10 kg/da P_2O_5, 18 kg/da K_2O as basal fertilizer VC: 0, 100, 200 and 400 kg/da Microbial Fertilizer: M- and M+	CF and VC	VC and M have the same effect with chemical	Altunlu, 2021
	'crispa'	Plastic Uncontrolled-Greenhouse	Ammonium sulphate: 15 kg N/da, triple super phosphate:10 kg P_2O_5/da, potassium sulphate: 15 K_2O/da kg VC: four different doses and control	CF and VC	Positive effect	Karademir, 2019
Straw-berries	Chandler	Greenhouse	CF: 85-155-125 kg/ha. VC: VCs produced from supermarket food wastes and recycled paper wastes were applied at rates of 5 or 10 t/ha	C	Vermicompost. No statistical difference between VC levels	Arancon et al., 2003
Corn	Pioneer P2088	Greenhouse	Basic Fertilizer before sown: 200 mg/kg N(NH_4SO_3), 100 mg/kg P and 125 mg/kg K (KH_2PO_4) VC: 0%, 10%, 20%, 30%, 40%, 50% (w/w)	C	Recommended: %40	Durukan, 2020
Ryegrass	Lolium perenne L.	Greenhouse	Municipal Compost (MC): 20% and 40% Municipal VC (MV): 20% and 40% Backyard VC (BV): 20% and 40%	VC	No generalization result regarding the higher quality of vermicomposts vs. composts	Tognetti et al., 2005
Mustard (Yellow)	Brassica compestris L.	Field	Vermicompost and compost (without earthworm): 0% (Control), 5%, 10%, 20%	VC	Positive effect Particularly %20 VC	Srivastava et al., 2011

3.2. The effect of vermicompost in field conditions

Applications conducted in the field are applied onto the natural soil. However, the own components of the soil alone are not affective and sufficient on the yield, quality, and sustainability of plants. Although chemical fertilizers rapidly facilitate plant nutrition, they tend to disturb soil structure, thereby posing disadvantages in terms of sustainability (Pek, 2023). As mentioned earlier, due to their adverse effects on both the environmental and human health, organic fertilizers is preferred. Vermicompost is among the preferred organic fertilizers that enhance soil productivity and quality. Like other fertilizers, vermicompost is also applied directly to the soil or mixed in the field conditions. For this, nutrient analyses of the soil and vermicompost are conducted, and fertilizer doses are determined performing necessary calculations.

It is known that the application of vermicompost in field conditions has a positive effect on plants such as peppers, tomatoes, strawberries, and watermelons (Arancon et al., 2003, 2004, 2005; Göksu and Kuzucu, 2017). In watermelons, two different doses of vermicompost were used under field conditions, and the highest values in fruit weight, fruit size, and plant yield were obtained with the application of 600 kg per hectare of vermicompost. Simultaneously, an increase in organic matter, phosphorus, and copper content in the soil was observed (Göksu and Kuzucu, 2017) (Table 1).

Najar et al. (2015) applied increasing doses of vermicompost to eggplant (2 tons/ha, 4 tons/ha, and 6 tons/ha), stating that as the doses increased, the germination rates also increased. The germination rate observed in eggplants treated with 6 tons/ha of vermicompost was 44%, while it was 35% at 4 tons/ha, and 21% in the control plants without any application. All growth characteristics and yield-related outcomes were highest at the 6 tons/ha vermicompost application rate (Table 1). These results also indicate that vermicompost application improves soil characteristics under field conditions.

Türkmen et al. (2020) have investigated effect of vermicompost and combined vermicompost with chemical fertilizer on tomato in field conditions (Table 1). They have used five different treatment: 1. Control groups, 2. 2,5 tones/da farm fertilizer, 3. 2.5 tones/da farm fertilizer with N:P:K/18:42:16 chemical fertilizer as full dose (100%), 4. 0,5 tones/da vermicompost and 5. 0,5 tones/da vermicompost with N:P:K/9:21:8 chemical fertilizer as half dose (50%). As a result of the study, vermicompost increased the yield of tomato, farm fertilizer was not effective compared to other treatments. Nevertheless, vermicompost combined with NPK was more efficient compared to only vermicompost. They have suggested that the combined use of vermicompost and chemical fertilizers could contribute to the reduction in the use of chemical fertilizers.

However, fertilization alone is insufficient to improve plant yield and quality and ensure sustainability. Ecological requirements such as temperature, light, and humidity for the plant should also be considered and provided. Controlling these factors in field conditions is quite challenging. Uncertain rainfall, wind, or temperature changes negatively affect the plant's development, resulting in undesired levels of yield. Additionally, pests and microbial pathogens pose a threat to the plant. Hence, greenhouses, where environmental factors can be controlled, are used (Chacha et al., 2023).

3.3. The effect of vermicompost in greenhouse conditions

Greenhouses are areas for cultivating plants enclosed in glass or plastic structures. Within greenhouses, just like in fields, direct sowing into the soil or in specific-sized pots is feasible. The ecological requirements of the plant can be controlled. However, this controllability is more effective in smart and modern greenhouses created with recent technologies. Chacha et al. (2023) examined the effect of field and greenhouse conditions on tomato plant development, noting a significant increase in growth parameters such as plant height, leaf count, flower, and fruit number in greenhouse plants. Vermicompost is also applied to the soil in greenhouses, similarly to field conditions. Studies have investigated the effect of vermicompost on various plants under greenhouse conditions, such as corn (Durukan et al., 2020), tomatoes (Wang et al., 2017), lettuce (Karademir, 2019), parsley (Peyvast, 2008), mustard (Srivastava et al., 2011), spinach (Özkan, 2016; Xu and Mou, 2017) (Table 1).

In a study on corn plants, different doses of vermicompost were applied, resulting in increased above-ground weight and an increase in nutrient element concentration and dry matter content. It was indicated that vermicompost could be used as an alternative to chemical fertilizers (Durukan et al., 2020) (Table 1), which holds significant importance for sustainability.

Lettuce is a food with high nitrate accumulation and excessive consumption of such foods can lead to toxic effects and diseases (Márquez-Quiroz et al., 2014; Zhang et al., 2019). Research on vermicompost in lettuce shows positive effects on plant yield, quality, and nutrient element content. To minimize nitrate accumulation and as an alternative to chemical fertilizers, a study applied 400 kg of vermicompost and microbial fertilizer per hectare, resulting in plant growth similar to chemical fertilization, with a substantial decrease in nitrate accumulation compared to chemical fertilization (Karademir, 2019; Altunlu, 2021) (Table 1).

According to Peyvast et al. (2008), vermicompost applied to the soil in the greenhouse increased plant height, leaf count, yield, and the quantity of certain nutrient elements in parsley plants. Another study conducted on mustard showed increases in root and stem length, branch, leaf, and flower numbers, as well as live and dry weights (Srivastava et al., 2011) (Table 1).

Tomatoes, commercially valuable plants, have been the subject of many studies on the effects of vermicompost on yield and quality. Several studies have particularly shown a positive impact on yield (Teke et al., 2019; Durukan et al., 2019; Gerusa et al., 2019; Wang et al., 2017; Calderon and Mortley, 2021). For instance, Wang et al. (2017) observed a 74% increase in tomato yield with the application of vermicompost in a greenhouse. Another study using increasing doses of vermicompost indicated an increase in tomato yield, with the best yield observed in plants treated with 160 grams of vermicompost per plant.

3.4. The effect of vermicompost in soilless conditions

Soilless refers to environments where nutrients are delivered to plants through water or air, enabling the transmission of essential elements without soil. When obtained through air, it's referred to as aeroponic; when obtained through water, it's termed hydroponic (Lakkireddy, 2012). As a modern and sustainable cultivation method, hydroponic systems involve growing plants in soilless environments using liquid nutrient solutions. These solutions contain fundamental nutrients like N, P, K, Ca, Mg, Fe, Zn, Cu, Mn and Mo, crucial for plant growth. They are vital to maintain the solution's electrical conductivity and pH levels continuously, as these levels are essential for nutrient concentration and uptake by the plants. These controls are maintained through smart systems and human intervention to achieve desired characteristics in yield and quality (Pomoni, 2023).

Supplemental fertilization is required based on the growth stages and needs of the plants in soilless systems. Therefore, plants are germinated on medias containing the aforementioned nutrients. After germination the seedlings is transplanted into the tubes added different substrate mixtures and this growing condition is principally combined with various chemical fertilizers (Haghigi et al., 2016). Fertilization is finely tuned and conducted in a fully controlled environment. Vermicompost provides organic matter containing vital elements such as nitrogen, phosphorus, potassium, and other trace elements essential for plant growth. Studies on the effect of vermicompost in soilless conditions are scarce compared to the other two environments.

In a study, the inclusion of vermicompost in hydroponic systems was reported to enhance the physiological development of tomatoes. Researchers have used 110-250 mg/L N, 60-140 mg/L P2O5 and 140-280 mg/L K2O as chemical fertilizer for germinating. After germinating vermicompost and municipal solid waste compost (MSWC) are separately treated. The use of vermicompost increased fresh and dry root weight, root volume and fruit number compared to control plants. Although vermicompost has positive effect on plant development, recommended treatment is MSWC:peat:perlite/25:25:50 (Haghighi et al., 2016).

In soilless-grown pepper plants, the application of vermicompost led to an increase in developmental features such as chlorophyll content, plant height, stem thickness, and fruit yield. In the study, six treatment are used, and each treatment (not control) has 5 g compose fertilizer (15-15-15) with transplanting and 7,5 g urea as chemical fertilizer for each 10 L pots. They investigated effect of waste mushroom compost, vermicompost and peat with 2500 ppm seaweed mixture and without it. Vermicompost and seaweed treatment have recommended in the study. (Aydın and Demirsoy, 2020) (Table 1).

Effect of soilless media on tomato nutrient uptake and yield have studied by Spehia et al. (2020). In the study, T1 growing media consists of vermiculite and vermicompost (70:30), T2 is cocopeat and vermicompost (70:30) and T3 is cocopeat and control. According to the results, adding vermicompost improved the quality and crop yield. Additionally the most effective combination was T2 treatment.

Soilless conditions were simulated for lettuce and tomatoes, and the effects of both solid and liquid vermicompost were examined. Different doses of liquid vermicompost were added to the nutrient solution, and the results were evaluated. According to the findings, in tomatoes and lettuce with the lowest application of vermicompost tea, higher yields were observed (Arancon, 2019). This suggests that minimal usage could suffice for plant yield, which also provides economic advantages. Parallel studies indicate an increase in germination, growth, flowering, and yield even with minimal mixing ratios in soilless-grown plants in greenhouses (Xu and Mou, 2017).

4. Conclusion

This study examines the effect of vermicompost on sustainable agricultural under some growing conditions, particularly in field, greenhouse, and soilless systems. Sustainable agriculture aims to provide future generations with a healthy food source and a habitable environment. Vermicompost is a natural fertilizer obtained through the decomposition of organic waste by earthworms, enhancing soil health while contributing to plant growth. The study reveals the positive effects of vermicompost on crops such as peppers, tomatoes, strawberries, and watermelons under field conditions. In greenhouse settings, it promotes the growth of tomatoes, lettuce, and mustard, demonstrating an increase in yield. In soilless systems, vermicompost has shown to improve the growth status of plants like tomatoes and peppers, enhancing their development. These findings emphasize that vermicompost can enhance plant cultivation conditions and increase seed productivity, positioning it as a significant component of sustainable agriculture. In most of these studies, vermicompost have been applied without chemical fertilizer treatment and some studies suggest that vermicompost should combine with chemical fertilizer, particularly soilless conditions. Nevertheless, it remains important for sustainable agriculture due to the reduced usage of chemical fertilizers in any case.

Considering various studies, it is evident that vermicompost is predominantly utilized in greenhouse and field conditions, yielding better results with its soil application. However, its liquid form alone does not yield significant advantages, indicating better outcomes when supplemented with additional fertilizers. Regardless of the cultivation environment, the use of vermicompost as a supplementary agent positively influences plant growth, yield, and quality. This highlights its significance as a crucial option for obtaining sustainable agricultural crops.

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