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Vegetable Crop Cultivation using Vermicompost in Comparison to Chemical Fertilizers: A Review

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ABSTRACT

The purpose of this paper is to review published literature which provides information to support the cultivation of vegetable crops using vermicompost in comparison to chemical fertilizers. With the systematic method, "Google Scholar," a web search engine which provides an easy way to search for published articles, journals or books was used to research works of literature on "Vegetable crops cultivation using vermicompost in comparison to chemical fertilizers." Then a subjective approach was used to select the themes that were discussed by reading through the abstracts and findings from the related works of literature. The subtopics discussed were: vermicompost, components of vermicompost, impacts of vermicompost, chemical fertilizers, components of chemical fertilizers, impacts of chemical fertilizers along with the use of vermicompost and chemical fertilizers on crops. The published papers established that vermicompost is an excellent organic medium which can be used to cultivate vegetable crops in comparison to chemical fertilizers because growing crops with vermicompost improves plant health with a positive influence on the yield and growth parameters of many plants, it has a high nutrient content, has pesticidal properties and slowly releases nutrients as compared to the chemical fertilizers which is depleted faster due to its release of nutrients too quickly. Chemical fertilizers on the other hand are useful in crop cultivation as it provides what is needed quickly but it has several negative impacts on plants, the soil and its surroundings.

Key words: Chemical fertilizer, Crops, Organic farming, Vermicompost.

Crops were typically cultivated using the traditional applications of inorganic fertilizer and pesticides over the centuries by the farmers. In addition, since the 1960s, heavy use of agrochemicals has increased food production at the detriment of the environment and society (Ganeshnauth *et al.,* 2018). It also killed beneficial soil microbes, disrupted their natural fertility, undermined the capacity of 'biological resistance' in crops, rendering them more vulnerable to pests and diseases. Conventional agricultural practices have also contributed to difficulties in plant growth, as nutrient levels in many soil types are volatile and may be inaccessible to certain plants. In addition, due to an increasing knowledge of the adverse economic and environmental effects of chemicals on crop production, the use of organic farming has been stimulated as the main method of farming. Since then, the revolution of vermicomposting studies has been initiated to increase crop production (Vennila *et al.,* 2012; Kovshov and Iconnicov, 2017; Ganeshnauth *et al.,* 2018; Kapila *et al.,* 2021; Mckenzie *et al.,* 2022).

Organic farming requires the use of organic materials without chemical inputs for the cultivation of crops (Arancon *et al.,* 2003). Organic manure for growing crops is a composition of waste materials. Owing to the steady rise in population size and improved living conditions around the world, the build-up of waste materials is becoming a burgeoning issue as these waste materials release hazardous compounds into the environment when burned. Burning also kills the soil's microbial community, destroys soil organic matter and changes the overall physical structure of the soil (Ansari, 2012). As a result, waste management can be maintained by using organic waste as a substrate in agriculture by organic farming. Composting of organic wastes provides a solution for a significant volume of waste throughout the world. Composting is a natural method for recycling decomposed organic materials into a nutrient rich soil known as compost (Arancon and Edwards, 2005). One of these composting strategies is vermicomposting, which will be addressed further in this paper.

As awareness of the adverse economic and environmental effect of chemicals on crop production has increased and the build-up of waste materials can be controlled by organic farming, the use of organic farming has been stimulated as the key method of farming today. Hence, the aim of this paper is to review published literature which provides information to support the cultivation of vegetable crops using vermicompost in comparison to chemical fertilizers because growing crops with vermicompost improves plant health and with favourable influence on growth parameters of many plants, has pesticidal properties and slowly releases nutrients as compared to the chemical fertilizers which is depleted faster

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due to its release of nutrients too quickly (Sinha *et al.,* 2010; Tharmaraj *et al.,* 2011; Ansari, 2020; Arjune and Ansari, 2022). The major subtopics being discussed are as follows; vermicompost, components of vermicompost, impacts of vermicompost, chemical fertilizers, components of chemical fertilizers, impacts of chemical fertilizers along with the use of vermicompost and chemical fertilizers on crops.

Vermiompost

Vermicomposting is a process by which earthworms break down organic waste materials, promote microbial activity and at the same time increase the mineralization rate of the soil. These practices transform waste materials to humus-like substances called vermicompost. Vermicomposts can be described as finely divided peat like materials ranging from a dark brown to black colour with a high water holding capacity, ideal structure, porosity and aeration. Vermicompost is an organic fertilizer which has a high nutrient content (Table 1) which is relatively free of any plant and human pathogens (Dominguez and Edwards, 2011; Ansari 2012; Vennila *et al.,* 2012; Ansari, 2020). It provides a wider area for microbial activity due to its increased surface area and it promotes better adsorption and retention of nutrients (Ansari and Ismail, 2012). Organic farming by the use of vermicompost will be an unpreventable method for sustainable agriculture for years to come, as vermicompost releases nutrients at a slow pace that encourages easy plant uptake and improves soil moisture keeping capacity resulting in improved crop quality (Dominguez and Edwards, 2011; Ansari, 2020; Kapila *et al.,* 2021).

Composition of vermicompost

Chemical Properties of Vermicompost

The vermicomposting process is an aerobic method of decomposition and mesophilic microbial activity is fully involved (Ramnarain *et al.,* 2018). Associated with the vermicomposting systems are complex food webs and there are several nutrient elements that undergo changes to various chemical forms that are eventually modified into stable organic compounds that are important in nutrient dynamics and plant growth regulators (Dominguez and Edwards, 2011; Dhakal *et al.,* 2015). The pH and soluble salt concentrations are discussed below.

Table 1: Physico-chemical properties of vermicompost (Ansari, 2012).

Parameters	Vermicompost
pH	6.12
Total salts (ppm)	3148.67
Total nitrogen (%)	1.11
Organic carbon (%)	9.77
C:N ratio	8.8
Available phosphate (ppm)	597.67
Calcium (ppm)	322.33
Magnesium (ppm)	137.33
Potassium (ppm)	2428.33
Manganese (ppm)	0.69
Copper (ppm)	0.11
Iron (ppm)	0.01
Zinc (ppm)	2.13

pH

In certain aspects of soil fertility and parameters of plant growth, the pH of soil or potting mixture to grow the plants is critical. The pH of the vermicompost varies according to the type of raw material used in the vermicomposting process and cattle dung produced vermicompost has a pH range of 6.0-6.7. During vermicomposting, the pH should be regulated between 6-7 to get the final vermicompost that is suitable for the ideal plant nutrient release (NPK and other micronutrients) and effective plant absorption (Edwards and Bohlen, 1996; Ansari, 2020; Kapila *et al.,* 2021).

Soluble salt concentrations

For seedlings and sensitive plants, the growth media or soil conditioners should have the soluble salt concentration (electrical conductivity) be below 100-200 mS/m and it should be less 200-300 mS/m for established plants. The effective process of vermicomposting usually ensures a low salt content which is due to the activity of earthworms. If the salt content is greater than 0.5%, the earthworm's activity will be affected (Edwards and Arancon, 2004).

Nutrient content of vermicompost

Total organic carbon

The total organic carbon in vermicompost is determined by the organic matter. The organic carbon content changes from the initial process of vermicomposting to the final stages, which is an important indicator of how the process is proceeding and stabilization occurs (Edwards *et al.,* 2011; Meena *et al.,* 2016; Ansari, 2020).

Total nitrogen

In vermicomposts, the range of the total nitrogen content differs and it depends on the type of organic input processed through vermicomposting. It varies from 0.1% to 4% and can be further increased by manipulating the nitrogen-rich starting material which is an important parameter for determining the quality of vermicompost in terms of use for different crop productions (Edwards and Bohlen, 1996; Ansari, 2020).

Carbon: nitrogen ratio

In the vermicomposting process, the carbon /nitrogen ratio is important and it normally reduces from the initial phase to the final stages which suggests vermicompost stabilisation. The C: N ratio should be below 20–22 at this stage (Edwards and Bohlen, 1996; Kovshov and Iconnicov, 2017).

Total phosphorus and potassium

When stabilized, the mature vermicompost should have the optimum macronutrients (phosphates and potassium) which are a quality indication. Generally, phosphates should be more than 0.5%. The total content of P and K in the finished vermicompost must be specified as it is an indication of the total value of the macronutrients. Seedlings and some phosphate-sensitive plants may need less than 0.1% (Edwards and Bohlen, 1996).

Total calcium and magnesium

Calcium and magnesium are critical to plant growth and these must be checked in mature vermicompost as it would contribute to the overall nutrient status (Edwards and Bohlen, 1996; Ansari, 2020).

Micronutrients (manganese, copper, zinc and iron)

Optimum quantities of micronutrients present in vermicompost are important as it relates to plant growth. In some situations, it is possible that excess micronutrient elements in vermicompost may be toxic to specific plants (Edwards and Bohlen, 1996; Kovshov and Iconnicov, 2017).

Other than the macronutrients and micronutrients mentioned above, vermicompost also contain growth promoting substances such as auxins and cytokinnins (Krishnamoorthy and Vajranabhiah, 1986).

Impacts of vermicompost

The use of vermicompost for planting has been highlighted in agriculture as a beneficial medium for improving plant growth, yield and the maintenance of soil fertility and this was supported by Arancon and Edwards (2005) as they showed that this organic matter improves the overall soil structure, soil fertility and crop yield. Organic farming is very advantageous and more sustainable economically than inorganic farming. Organic farming controls pests and diseases without affecting the surroundings/environment, prevents pollution and improves soil fertility, so that crops yield enough nutrients and to attain higher marketable prices. Vermicompost is one of the best organic planting media in the world. Vermicompost is eco-friendly as it highly organic and does not contain any chemicals. It is more nutritious and releases nutrients at a slow pace that is quickly absorbed by plants and reduces the need for pesticides because plants are safer and free from pests and diseases (Arancon and Edwards, 2005; Kovshov and Iconnicov, 2017).

Chemical fertilizer

Industrially produced fertilizers are often referred to as “mineral” fertilizers containing varying proportions of plant essential elements (N, P, K, *etc.*) and minor elements (Zn, Mn, Fe, *etc.)* as well as impurities (Table 2) and other non-essential elements (Heinz-Ulrich, 1993).

When chemical fertilizers are frequently applied to plants, it causes the leaves to turn yellow or brown, as the plant has a foreign substance on its body that is not normal and the plant is not used to the time of mineral intake. This will damage the plant and reduce the yield of the crop. In particular, the leaves of the plant begin to wither and, in extreme cases, the plant may die (Chandini *et al.,* 2019).

Chemical properties of chemical fertilizer

The specific chemical properties of fertilizers are complex and varied. Properties to consider are: solubility, particle size, soil pH, chemical form and soluble salts Heinz-Ulrich, 1993).

Table 2: Nutrient content of chemical fertilizer (Chandini *et al.,* 2019).

Primary macronutrient	Secondary macronutrient	Micronutrient
Nitrogen	Calcium	Copper
Phosphorous	Magnesium	Iron
Potassium	Sulphur	Manganese
		Zinc
		Boron
		Silicon
		Cobalt
		Vanadium
		Molybdenum

Impacts of chemical fertilizer

Agricultural systems throughout the word use a large number of chemicals such as fertilizers, pesticides, herbicides to produce more output per unit area, but using more than the optimal or recommended doses of these chemicals and fertilizers which causes a number of problems such as environmental contamination (soil, water, air pollution), reduced input productivity, reduced food quality, resistance to different types of weeds, diseases, insects, soil erosion, micronutrient deficiency in soil, toxicity to different beneficial living organism present above and below the soil surface, less income from the production, *etc.* (Chandini *et al.,* 2019).

Despite so many obstacles, there is still a challenge to fulfill the needs of the world’s population which is increasing. Hence, there is the need to produce nutrient rich and chemical free agricultural products for human and animal consumption without degradation of natural resources, which is why focus should be put on the production of food in terms of quality and quantity (Chandini *et al.,* 2019). The use of chemical fertilizers is advantageous to plants as it supplies plants with missing nutrients; they also have a variety of other conveniences, thus immediate availability, which makes them more appropriate than organic fertilizers. There is ample evidence that inorganic fertilizers can substantially increase crop yields (Heinrich *et al.,* 2005). They increase soil fertility in such a way that crop yields are independent and no longer constrained by the lack of plant nutrients (Ojeniyi, 2000). Despite these advantages, fertilizers have a range of negative effects on the environment due to increased use and decreased productivity in the usage of nutrients. The key challenge in intensive farming systems is therefore to combine intensive cultivation with high nutrient efficiency (Ojeniyi, 2000).

Use of vermicompost versus chemical fertilizers on crops

Vermicompost used in organic farming produces higher yield of crops which are safer and chemical free when compared to plants grown with chemical fertilizers. It also enhances flowering and physical properties of the fruits (Ismail, 2005; Jaikishun *et al.,* 2014; Kovshov and Iconnicov, 2017; Ansari, 2020). The availability of nutrients from vermicompost is readily available to plants whereas with chemical fertilizers it has to be broken down first before the plant can obtain the nutrients. Also, the humus in the vermicompost gives it a greater water holding capacity than chemical fertilizers which needs a lot of water for irrigation (Singh *et al.,* 2010; Sundararasu and Neelanarayanan, 2012; Jaikishun *et al.,* 2014; Kovshov and Iconnicov, 2017). The properties of the vermicompost which promotes plant growth are the fact that they are rich in bio nutrients which are required for the growth of plants, these includes nitrates, phosphates, soluble potassium, magnesium and exchangeable phosphorus and calcium (Arancon and Edwards, 2005; Kapila *et al.,* 2021).

A study done in 2014 to compared the effects of vermicompost and chemical fertilizers (NPK) on growth and yield of common bean, at Tehran, Iran using the randomized complete block design with six (6) treatments (T1: 100% recommended dose of NPK; T2: 100% recommended dose of vermicompost; T3: 50% vermicompost + 50% NPK; T4: 75% vermicompost + 25% NPK; T5: 25% vermicompost + 75% NPK and T6: control) with four (4) replications. Sadeghipour (2017), found that the highest leaf area index, relative water content, plant height, biomass, number of pod, number of seed per pod, seed weight and seed yield were achieved by using 100% recommended dose of vermicompost and the lowest value of all measured traits was obtained in the control treatment. According to this study, vermicompost may be used instead of chemical fertilizers in common bean cultivation and other than improving the soil characteristics, chemical contamination of soil, water and plants is also reduced (Sadeghipour, 2017).

Aracnon *et al.* (2003) evaluated the effects of vermicompost and chemical fertilizer on growth and marketable fruits of field-grown tomatoes, peppers and strawberries and they found that the marketable tomato yields in all vermicompost-treated plots were greater than the yields from the inorganic fertilizer-treated plots. Significant increases were seen in shoot weights, leaf areas and total and marketable fruit yields of pepper plants from plots treated with vermicompost when compared to those from plots that were treated with inorganic fertilizer only. Leaf areas, numbers of strawberry suckers, numbers of flowers, shoot weights and total marketable strawberry yields increased significantly in plots treated with vermicompost when compared to those with the inorganic fertilizers.

Troung *et al.* (2018) evaluated the effects of vermicompost in media on the growth, yield and fruit quality of cherry tomato under net house conditions and the study revealed that the pH, EC, N, P, K, Ca and Mg available in media increased significantly following the addition of vermicompost. The study also revealed that the addition of vermicompost improved the physic-chemical properties of the media, increased the EC and along with the macronutrients in the media resulting in significant increases in the yield and quality of tomato fruits (Troung *et al.,* 2018).

Wang *et al.* (2018) replaced inorganic fertilizer with organic fertilizers for one full growing period on soil fertility, tomato yield and quality using soils with different tomato planting history and they found that vermicompost can be used as a fertilizer to improve tomato fruit quality, yield and soil quality, particularly for soils with no tomato planting history.

A study investigated the effects of vermicompost on the growth and productivity of eggplant (*Solanum melongena*) under field conditions found that the different treatments affected the seed germination of the test crop significantly. Plant height, number of leaves and fruit weight were higher in the vermicompost treated field when compared to control and no disease incidence was observed in the fruits treated with vermicompost. The study also revealed that the application of vermicompost affected the eggplant crop differently and they recommend that farmers should use vermicompost instead of inorganic fertilizers when cultivating eggplants (Mamta *et al.,* 2012).

Bellitürk (2018) investigated the effects of increasing the doses of vermicompost applications on P and K contents of pepper *(Capsicum annuum* L.) and eggplant *(Solanum melongena* L.*)* in 2017 and results from the study have shown that the use of vermicompost increased the P and K contents in both the eggplant and pepper plants. From the results, the researchers recommend that vermicompost can be used to cultivate peppers and eggplants.

CONCLUSION

This review emphasized on the importance of using vermicompost versus chemical fertilizers for the cultivation of vegetable crops as vermicompost is organic, inexpensive, eco-friendly and most importantly it contains a lot of nutrients which results in better yields and growth parameters. Although chemical fertilizers are effective in crop cultivation, they have several negative impacts as they affect the soil along with the surroundings, they reduce food quality, they are expensive, *etc*. More research should be done when it comes to crop cultivation using vermicompost against chemical fertilizers especially in Guyana. A lot of papers focused on mainly two (2) crops (tomato and sweet peppers) hence, research should be done on crops others than those mentioned.

Conflict of interest: None.

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