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Evaluation of Vermicompost and its Application Effect on Growth and Yield of Tomato (*L. esculetum*) in Wondo Genet, Ethiopia

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Abstract

To evaluate vermicompost on tomato productivity, a field experiment was conducted at Wondo Genet Agricultural Research Center. Factorial combination of N rates from vermicompost (based on N equivalence) and application period was the treatments. Nitrogen rates was had levels of full dose from inorganic N, 50% of the RN from vermicompost, 75% of the RN from vermicompost, 100% of the RN from vermicompost and 150% of RN from vermicompost. Application period had levels of 35, 20 days before planting and at planting. The design was used RCBD with three times replication for each treatment. The obtained results from the present research indicated that, the application rate and timing of vermicompost, clearly, had influences on tomato productivity. Application of vermicompost had significant ($p < 0.01$) effect on tomato above ground biomass and tomato yield, but not on plant height and fruit diameter. The highest yield of tomato (12338 kg ha-1) and above ground biomass (12975kg ha-1) were obtained from the application of 100% of the recommended nitrogen from vermicompost 30 days before planting, respectively. Additionally, higher tomato plant height (80.97 cm) and fruit diameter (36.26 cm) were obtained from the application of 100% of the recommended nitrogen from vermicompost 30 days before planting. From the study the minimum Yield and yield components were obtained at the application of full dose from inorganic nitrogen alone and statistically inferior with that of rest trials. Accordingly, application of vermicompost of 100% of the recommended nitrogen from vermicompost 30 days before planting could be recommended to achieve optimum yield of tomato in the study area.

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Keywords

Growth, yield, tomato, Vermicompost application rate, Application timing.

Introduction

Now a day the world population has faced two challenges. The first is adverse climate change because of uncontrolled greenhouse gas emission and the other is health related problem attributed to inorganic product consumption. Organic inputs, on the other hand, partly substitute inorganic fertilizer and hence contribute in reduction of fuel burning that meant for inorganic fertilizer production as well as minimize emissions due to volatilization and denitrification losses. Moreover, the integration of organic inputs to agriculture would enrich the quality of produces.

This will improve the health of the consumers and improve the benefit that growers would obtain. The concepts of using organic fertilizers and even composting, though conventional, have been with Ethiopian farmers for couple of decades. However, the practice on organic fertilizer production and use has remained to be quite traditional. Different local producers of compost do the composting work from predetermined sources, in own procedure and even apply haphazardly. The absence of commercial compost producer at a country level might have contributed much to the problem. Research will also have an irreplaceable role to end these irregularities through standardizing the system. The functional relationship of volume and proportion of source, duration, volume and quality of product, and yield improvement per unit dry weight product need to be established for major agroecology's (Kedir Jemal and Asegedch Abebe, 2020).

An additional benefit of recovering and reusing nutrients from waste streams is that it enables organic matter to be returned to the soil, playing a crucial role in the maintenance of good overall soil health and functions including nutrient cycling and soil fertility. Functional relationship of proportion of sources, duration, volume and quality of organic product, and their role on the crop productivity need to be established for major crops, soils and agroecology's. In other hand, recycled nutrients provide an important share of total nutritional requirements for crop production, there is scope to increase this contribution by recovering and reusing nutrients from other waste streams (Agarwal, 1996).

Although, industrial fertilizer has helped to improve crop production, its escalating price caused by increased fossil fuel prices has seriously limited its use. On the other hand, the application of chemical fertilizers over a long period has resulted in poor soil health, reduction in produce, and increase in incidences of pest and disease and environmental pollution (Reshid Abafita1 *et al.*, 2014).

Accordingly, production potential of food crops is still low and as a result producer are now looking for other alternatives to these fertilizers. Therefore, in order to reduce costs and adopt more environmentally-friendly practices, research on alternative substrates is of great interest, and several alternatives have been proposed. Organic fertilizers play significant role in improving soil fertility and increasing crop production and productivity. The most common types of organic fertilizers are farm yard manures, compost, vermicompost, etc. (Kedir Jemal and Asegedch Abebe, 2020).

The new approaches to the use of organic amendments in farming system have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Composting has been recognized as a low cost and environmentally sound process for treatment of many organic wastes (Hoitink *et al.*, 1993). A process related to composting which can improve the beneficial utilization of organic wastes is vermicomposting. Vermicompost, as a mesophilic biodegradation product resulting from interactions between earthworms and microorganisms in the breakdown of organic wastes (Edwards, 1983).

Vermicompost (VC) has a direct effect on plant growth, and it is a product with great commercial potential (Atiyeh *et al.*, 2002). It consists of a chemical mixture of minerals composed of low amounts of salts having a large ion exchange capacity (Atiyeh *et al.*, 2000a), and provide substances involved in plant growth regulation (Tomati *et al.*, 1990). These active substances, such as nitrates, phosphorus and soluble aggregates (potassium, calcium and magnesium), are easily assimilated by plants (Orozco *et al.*, 1996). Bduli *et al.*, (2011) indicate that the mixture of vermicompost with inorganic fertilizers increase crop yields, compared to those who only use the latter; Tomati *et al.*, (1990) its application also improves the quality of vegetables and nutrient levels are higher than in traditional crops (Agegnehu and Amede, 2017). In the vermicomposting process many nutrients are changed to their simplest form, facilitating its absorption by the plant (Atiyeh *et al.*, 2000b).

Vermicompost are characterized by high porosity, aeration, drainage, water-holding capacity and microbial activity. Many studies have demonstrated positive effects of vermicompost on a wide range of crops, including cereals and legumes, ornamental, and flowering plants, vegetables (Edwards, 1983; Atiyeh *et al.*, 2000a), and field crops. Application of compost and vermicompost can also increase soil organic carbon, nitrates, phosphates, exchangeable calcium and some other nutrients for plants (Orozco *et al.*, 1996).

Most of these investigations have confirmed that manure compost and vermicompost usually has significant beneficial effects on plant growth. However, there have been very few experimental investigations exploring effects of vermicompost and manure compost applications on tomato (Albertson *et al.*, 2001).

Traditionally farmers used to apply these fertilizers understanding the benefits they have in increasing soil fertility as well as crop productivity. However, the small-scale farmers lack information on the exact rate, quality, and of course alternate sources of these fertilizers. In this line research has a lot to do and recommend the extension system on how to prepare, and use these agricultural inputs properly for sustainable crop production. Hence, currently the research system has given due attention to organic fertilizers research and product development parallel to others. Therefore, the objective of this study was to evaluate vermicompost characteristics and appropriate rates and period of vermicompost applications on the growth and yield of tomato cultivation.

Materials and Methods

Description of the study area

To evaluate vermicompost on tomato productivity, a field experiment was conducted during December to April of 2020 cropping seasons at Wondo Genet Agricultural Research Center. It is geographically located at 07° 03' 19.1" to 07° 04' 00.2" North latitude and from 38° 30' 08.4" to 38° 31' 01.8" East longitude. It receives mean annual rainfall of 1128 mm and minimum and maximum temperature of 11 and 26°c, respectively. The soil textural class of the experimental area is clay loam with a pH of 6.4.

Experimental design and procedure

Factorial combination of N rates from vermicompost (based on N equivalence) and application period was the treatments. Nitrogen rates was had levels of full dose from inorganic N, 50% of the RN from vermicompost, 75% of the RN from vermicompost, 100% of the RN from vermicompost and 150% of RN from vermicompost. Application period had levels of 35, 20 days before planting and at planting. The design was used RCBD with three times replication for each treatment. The methods used for mass rearing and maintaining of earthworms in Wondo Genet Agricultural Research Center were used for vermicompost preparation.

The materials were produced using the same inputs – cattle manure, with straw used as bedding for the vermicomposting and bulking in the composting process the products were dried, screened, and applied as a treatment. TN (%) analysis will be done for vermicompost to arrange treatments before application. Incorporation of the vermicompost to 15-20 cm depth will be made just after application. Non-treatment nutrients such as P, etc. will be applied in uniform condition based on the recommendation to the specific implementing location.

Data collection and analysis

Before commencement of the experiment physical and chemical characteristics of vermicompost and soil used were examined based on appropriate procedures. Agronomic data such as Yield/plant, fruit diameter, plant height and above ground biomass data was collected from the randomly selected five central plants from each plot. Border rows and plants were excluded from the sampling to minimize border effect on yield and yield components of tomato. The data collected were statistically analyzed using statistical analysis system (SAS) software version 9.4 using the general linear programming procedure (GLM). Mean comparison was carried out using least significant difference (LSD) at a 5% probability level to compare the differences among the treatments mean.

Results and Discussion

Table 1 shows that soil had a lower pH, EC, P and Cu, compared to vermicompost. The vermicompost contained high concentrations of organic material, silt and clay and was also rich in many soil nutrients such as, nitrogen, Sulphur, potash, phosphorus, calcium, magnesium, etc. Vermicompost was also rich in growth hormones and vitamins and thus acts as a powerful biocide against diseases and nematodes (http://www.tribuneindia.com/20010305/ agro.html). Earthworm castings contain abundant essential elements that plants need for healthy growth (http://www.louisvillehydroponics). com/organic.html). research findings show that analysis of earthworm castings reveal that they are richer in nutrients than surrounding soils, often having 3 times more calcium, and several times more nitrogen, phosphorus, and potassium (http://www.earthwormvietnam. com/ index.html). There is a close relationship between the nutrient status of soil and organic matter content. vermicompost contained plant nutrients in addition to its action as soil conditioners. This all adverse positive effect of vermicompost substitution may cause adverse effects on plant growth and yield (Arancon *et al.,* 2004).

Consistent previous researches have shown that the addition of vermicompost raises soil fertility and yields to levels greater than those under synthetic fertilizer treatments. In addition to directly supplying nutrients from the mineralization of organic matter, the mechanisms of higher availability of nutrients with soils of higher organic matter contents are multiple (Chong, 2005). Ansari and Sukhraj (2010) showed that the addition of compost to soil generally improves tilth, soil structure, infiltration, drainage, and water-holding capacity. Chaoui *et al.*, (2003) reported that the supply of cattle manure vermicompost has become a profitable activity for many producers.

Yield and yield components

Application of vermicompost had significant ($p < 0.01$) effect on tomato above ground biomass and tomato yield, but not on plant height and fruit diameter (Table 2). The highest yield of tomato (12338 kg ha-1) and above ground biomass (12975kg ha-1) were obtained from the application of 100% of the recommended nitrogen from vermicompost 30 days before planting, respectively. (Table 2). Numerically higher tomato plant height (80.97 cm) and fruit diameter (36.26 cm) were obtained from the application of 100% of the recommended nitrogen from vermicompost 30 days before planting even if, statistically significant differences were not observed among vermicompost applications. From the study the minimum Yield and yield components were obtained at the application of full dose from inorganic nitrogen alone and statistically inferior with that of rest trials.

Higher yield and yield components were found after the treatments with vermicompost, which is consistent with previous research showing that crop plants had increased height after vermicompost was applied in our case, the application of different concentration of vermicompost showed increased accumulation of N, P, and K, which intern, resulted in increased yields and yield components and soil quality parameters as well. The observed changes in plant growth and yields could be as a result of buffering activities of vermicompost and improved nutrition. The obtained results from the present study indicated that the application of the used vermicompost led to better growth and development of vermicompost treated plants as they were shown with higher yield and yield components of tomato. Level of significance could result from the improved nutrition, stimulated rooting, and induced changes of metabolic process and achievement of neutral pH at 100% of the recommended nitrogen from vermicompost treated planting media (Kedir Jemal and Asegedch Abebe, 2020).

According to reports from Togun and Akanbi (2003), tomato fruits fertilized with vermicompost reach an average individual weight of ~ 120 g, because the nutrients available to the plant from vermicompost favor the production of larger and heavier fruits (Shankar *et al.*, 2012). Vermicompost had an effect on tomato weight and size, since the essential nutrients in the applied vermicompost are similar to those reported by Atiyeh *et al.*, (2000b) and Shankar *et al.*, (2012), who mention that vermicompost provide the nutrients needed for a good plant development. The structural improvement of the cultivation soil favors the activity of microorganisms, which influence the exchange of nutrients and the plant potential to grow and increase the production volume of tomato (Arancon *et al.*, 2004). The nutrients in a medium such as vermicompost are assimilated by the plant in higher concentration since they have greater bioavailability as observed in the present study, thereby supporting plant growth and development in a relatively short time, leading to an earlier onset of fruit formation and production compared to the control plants.

Previous studies suggest that an integrated soil fertility management approach may have more sustainable agronomic and economic impact than a focus on chemical fertilizer alone. Agegnehu and Amede (2017) also indicated that application of vermicompost and fertilizer improved plant growth and doubled grain yield in comparison to fertilizer alone.

Because of escalating price of industrial fertilizer its use become seriously limited. On the other hand, the application of chemical fertilizers over a long period has resulted in poor soil health, reduction in produce, and increase in incidences of pest and disease and environmental pollution. Understanding the soil resource in an area and adoptions of management options to improve the productivity of soils is necessary for sustainable use. Use of vermicompost and other organic amendments has been proved to enhance agricultural productivity significantly by improving soil properties such as soil pH, electrical conductivity, organic carbon, total nitrogen, available phosphorous, CEC and exchangeable cations. vermicompost applications also significantly increased growth and yield of tomato.

These studies should be designed to elucidate the impacts of organic fertilizers on soil microbial processes and nutrient cycling on different soil types, to increase tomato yields under sustainable production systems. Optimizing fertilizer management to maximize yields and quality while reducing the use of inorganic fertilizer and maintaining good-quality soil. Accordingly, application of vermicompost of 100% of the recommended nitrogen from vermicompost 30 days before planting could be recommended to achieve optimum yield of tomato and improve soil fertility of the study area.

Table. 1 Selected chemical characteristics of the experimental soil and vermicompost used for the study

Parameter	Element concentration	Parameter	Element concentration
Experimental soil		vermicompost	
pH-H2O	6.4	pH-H2O	7.42
Organic C (%)	1.81	Organic C (%)	4.75
Total N (%)	0.20	Total N (%)	2.06
Available P (mg/kg)	9	Available P (mg/kg)	31.56
CEC (meq/100g)	19.8	CEC (meq/100g)	39.10
Exchangeable K (cmol/kg)	-	Exchangeable K (cmol/kg)	18.38
Exchangeable Na (cmol/kg)	0.08	Exchangeable Na (cmol/kg)	3.19
Exchangeable Ca (cmol/kg)	9.15	Exchangeable Ca (cmol/kg)	50.39
Exchangeable Mg (cmol/kg)	2.51	Exchangeable Mg (cmol/kg)	14.36

C = carbon; N= nitrogen; P = phosphorous; CEC = cation exchange capacity

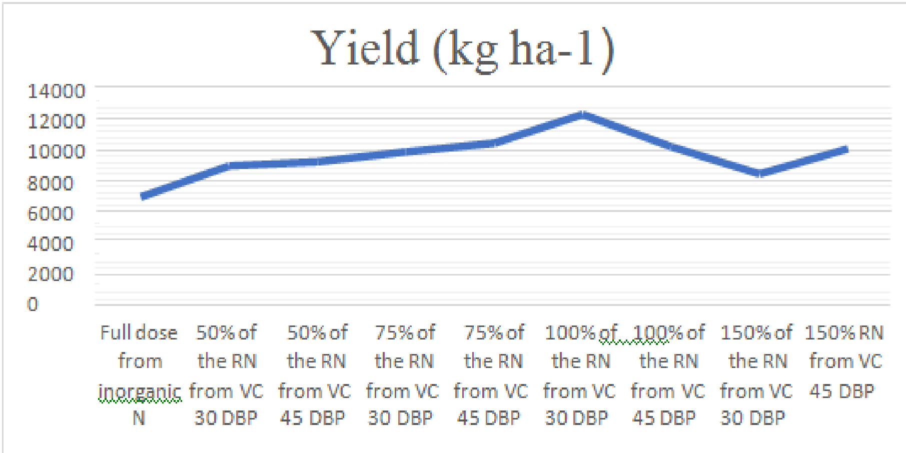
Table. 2 Effect of vermicompost application rate and time on yield and yield components of tomato

Treatments	PH (cm)	FD (cm)	Yield (kg ha^{-1})	AGB (kg ha^{-1})
Full dose from inorganic N	71.80	32.79	6946^{c}	**7357^{c}**
50% of the RN from VC 30 DBP	74.80	32.96	8977^{bc}	**9353^{bc}**
50% of the RN from VC 45 DBP	73.96	34.44	9246^{b}	**9742^{b}**
75% of the RN from VC 30 DBP	75.63	33.26	9888^{b}	**10294^{b}**
75% of the RN from VC 45 DBP	78.86	34.87	10457^{ab}	**11073^{ab}**
100% of the RN from VC 30 DBP	80.97	36.26	12338^{a}	**12975^{a}**
100% of the RN from VC 45 DBP	73.23	32.43	10226^{ab}	**10798^{ab}**
150% of the RN from VC 30 DBP	76.67	33.50	8444^{bc}	**9038^{bc}**
150% RN from VC 45 DBP	76.83	33.94	10092^{ab}	**10569^{b}**
LSD 0.05	NS	NS	2278.6	**2206.6**
CV (%)	**4.99**	**20.64**	**13.6**	**12.58**

*. **, ***Significant at p<0.05, p<0.01 and p<0.001, respectively; NS= not significant. Means with the same letter in column are not significantly different at p<0.05; LSD: Least Significant Difference; PH: plant height, AGB: above ground biomass, FD: Fruit diameter, VC: Vermicompost, DBP: Day before planting and RN= recommended nitrogen.

Fig.1 Vermicomposting Technologies

Fig.2 Yield of Tomato under Different Rate and Time Application Vermicompost



Data Availability

The data used to support the findings of this study are included in the results part of the manuscript

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

Kedir Jemal conducted over all activities such as proposal writing, literature review, data collection and statistical analysis, and manuscript write-up.

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