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Full Length Research Paper

Evaluation the Effect of Verm-compost Application Rates and Period of Application on Growth, Yield of Hot pepper (Cupsicum annuum) and Soil Fertility Status in Asossa district, western Ethiopia

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Abstract

Hot pepper (Capsicum annuum L.) is the most important crop consumed as a vegetable (green fruit) and spice (dry fruit) in the world (Bosland and Votava 2000). Hot pepper (Capsicum annuum species) is an economically important crop belonging to the family of Solanaceae (Bosland and Votava, 2000). The productivity of hot pepper is still constrained by a lack of proper nursery yield, a limiting factor in vegetable crop production in Ethiopia (Alemu and Ermias, 2000). According to the Ethiopian Export Promotion Agency (Ethiopian Export Promotion Agency, 2003) report, hot pepper is a high-value and important cash-generating commodity for small-scale farmers in Ethiopia. Application of balanced fertilisers is the basis for producing more crop output from existing land under cultivation (Caruso et al., 2019). It enhances sustainable production and provides nutrient needs to crops according to their physiological requirements and expected yields (Ryan, 2008). Previous fertiliser research work in Ethiopia has been focused on nitrogen (N) and phosphorous (P) fertiliser sources under different soil types and various climatic conditions, while very limited work has been reported with other essential macro- and micro-nutrients (K, S, Fe, Zn, B, etc.). Low soil fertility is one of the bottlenecks to sustaining agricultural production and productivity in Ethiopia. Application of chemical fertilisers in the crop field contributes greatly to the deterioration of the environment, loss of soil fertility, less agricultural productivity and soil degradation (Imbar et al., 1993). Compared to inorganic fertiliser, organic manure is readily available to the farmers, and the price is also low (Alem et al., 2007). Cow manure vermicompost could be used as an excellent soil amendment for main fields and nursery beds and has been reported to be useful in raising nursery species plants (Chanda et al., 2007). Vermicomposting means the use of earthworms for composting organic residues.

Keywords: Verm-compost Application, Growth, Yield of Hot pepper (*Cupsicum annuum*), Soil Fertility

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INTRODUCTION

Hot pepper (*Capsicum annuum L.*) is one of the most widely cultivated vegetable and spice crops globally, valued both for its culinary versatility and nutritional attributes (Bosland & Votava, 2012; Wahome et al., 2020). It belongs to the family Solanaceae and is grown across diverse agroecological zones, contributing significantly to food security, income generation, and agro-industrial raw material supply. In Ethiopia, hot pepper is among the most important cash crops for smallholder farmers, cultivated for domestic consumption and export markets (Ethiopian Export Promotion Agency, 2003). Despite its economic importance, production in the country remains suboptimal due to constraints such as poor nursery management, nutrient deficiencies, pest and disease pressure, and limited adoption of improved agronomic practices (Alemu & Ermias, 2000; Taye et al., 2021).

Soil fertility depletion is a key factor limiting vegetable crop productivity in Ethiopia. The decline in soil nutrient status, caused by continuous cropping, soil erosion, and minimal organic matter inputs, has been widely reported as a major challenge to sustainable agriculture in sub-Saharan Africa (Vanlauwe et al., 2015). Historically, fertiliser research in Ethiopia has focused primarily on nitrogen (N) and phosphorus (P) inputs, often overlooking other essential macro- and micronutrients such as potassium (K), sulphur (S), zinc (Zn), and boron (B) (Agegnehu et al., 2016). While the use of chemical fertilisers has contributed to yield improvements, long-term reliance on inorganic sources alone has been associated with soil acidification, nutrient imbalances, reduced organic matter, and environmental degradation (Tilahun et al., 2020). This has created the need for sustainable soil fertility management strategies that combine nutrient supply with soil health restoration.

Organic amendments such as vermicompost offer a promising alternative to purely chemical-based nutrient management. Vermicomposting is a bioconversion process in which earthworms decompose organic residues into a nutrient-rich, humus-like product containing plant-available forms of nitrogen, phosphorus, potassium, and micronutrients (Edwards, 2011; Lazcano & Domínguez, 2011). In addition to nutrient enrichment, vermicompost improves soil structure, water-holding capacity, cation exchange capacity, and microbial diversity (Hargreaves et al., 2008; Arancon et al., 2010). The large particulate surface areas of vermicompost provide microhabitats that enhance microbial colonisation and nutrient retention (Shi-wei & Fu-zhen, 1991), while its slow-release properties ensure a steady nutrient supply throughout the crop growth cycle.

Several studies have demonstrated the positive effects of vevermiculite on horticultural crops, including enhanced germination, improved plant vigourhigher yields, and better fruit quality (Atiyeh et al., 2000; Sinha et al., 2010). For hot pepper specifically, research in tropical and subtropical contexts has shown that vermicompost can increase plant height, leaf number, and fruit yield, while reducing dependency on synthetic fertilisers (Ndangui et al., 2022; Suthar & Singh, 2008). Furthermore, vermicompost applications have been linked to higher soil organic carbon and beneficial microbial populations, both of which contribute to long-term soil fertility (Singh et al., 2011). Despite these promising findings, empirical evidence from Ethiopian conditions—especially for specific application rates and timing—remains scarce.

In Ethiopia's western agroecological zones, particularly in the Asossa district, hot pepper production is constrained not only by soil nutrient depletion but also by limited access to affordable and environmentally sustainable soil amendments. Vermicompost, which can be produced locally from farmyard manure and crop residues, offers an accessible solution for smallholders. However, there is limited scientific information on the optimal rates and periods of vermicompost application for maximising hot pepper yield and improving soil fertility in this region. Without such data, farmers risk under- or over-application, potentially reducing economic returns or causing nutrient losses.

Therefore, this study was undertaken to evaluate the effect of different vermicompost application rates and periods on the growth, yield, and soil fertility status of hot pepper (*Capsicum annuum L.*) in Asossa district, western Ethiopia. The findings are expected to provide evidence-based recommendations for farmers, extension workers, and policymakers seeking to promote sustainable vegetable production systems in the region. Moreover, the results will contribute to the broader discourse on organic soil fertility management as a viable complement to chemical fertiliser use in smallholder agriculture.

MATERIALS AND METHODS

Description of the Study Sites

The experiment was conducted in Benishangul-Gumuz Regional State, at the Asossa Agricultural Research Centre (AARC) research farm in the 2016/17 main cropping season under rainfedfield conditions. Benishangul-Gumuz Regional State is geographically located at 9°30' to 11°39' N latitude and 34°20' to 36°30' E longitude, covering a total land area of 50,000 square kilometres. The study site is located at 10° 02' 05'' N latitude and 34° 34' 09'' E longitude. The study area is situated east of Asossa town and west of Addis Ababa at distances of about 4 km and 660 km, respectively. Asossa has a unimodal rainfall pattern, which starts at the end of April and extends to mid-November, with maximum rainfall received from June to October. The total annual average rainfall of Asossa is 1275 mm. The minimum and maximum temperatures are 16.75°C and 27.92°C, respectively. The dominant soil type of the Asossa area is Nitosols, with the soil pH ranging from 5.0 to 6.0.

Treatments and Experimental Design

The treatments were laid out in randomized complete block design with three replications. Hotpeper variety (Marikofana) was used as test crop. The two factorial RCBD (four verm-compost rates and three application period of verm-compost) were used as the factors. Totally thirteen treatments which include: one national recommended of Urea as positive control, four rates of verm-compost and three application period of verm-compost were used as treatments. Blended fertilizers and TSP were basal applied at planting and Urea was top dressed twice (at knee height and tasseling). The plot size of 2.8 m x 3 m (8.4 m2) was used. The crop was planted in rows with recommended spacing (60 x 20 cm) the space between row and plant respectivelly. The other crop management practices were applied uniformly for all plots as per the recommendation for the crop.
The treatments include:
Factorial combination of N rates from vermicompost (based on N equivalence) and application period

Treatment Structure: Fertilizer Sources, Rates, and Application Periods

Treatment	Fertilizer source (rates)	Application period
1	Full dose from inorganic N	At planting
2	50% of the RN from vermicompost	At planting
3	75% of the RN from vermicompost	
4	100% of the RN from vermicompost	
5	150% of the RN from vermicompost	
6	50% of the RN from vermicompost	20 days before planting
7	75% of the RN from vermicompost	
8	100% of the RN from vermicompost	
9	150% of the RN from vermicompost	
10	50% of the RN from vermicompost	35 days before planting
11	75% of the RN from vermicompost	
12	100% of the RN from vermicompost	
13	150% of the RN from vermicompost	

Soil and verm-compost sampling and analysis

The chemical properties studied included pH, CEC, exchangeable acidity, exchangeable bases (Ca, Mg, Na, K), organic carbon, total nitrogen, and available P, which were analysed for vermicompost of all years.

The pH was determined using a pH meter with a combined glass electrode in water (H_2O) at a 1:2.5 soil:water ratio as described by Carter (1993). Organic carbon was determined by oxidising carbon with potassium dichromate in sulphuric acid solution following the Walkley and Black method (1934). Finally, the organic matter content of the soil was calculated by multiplying the organic carbon percentage by 1.724. The total nitrogen contents in soils were determined using the Kjeldahl procedure by oxidising the organic matter with sulphuric acid and converting the nitrogen into NH_4^+ as ammonium sulphate (Sahlemedhin and Taye, 2000).

Exchangeable bases (Ca, Mg, K and Na) in the vermicompost were estimated by the ammonium acetate (1M NH_4OAc at pH 7) extraction method. In this procedure, the vermicompost samples were extracted with excess NH_4OAc solution, and Ca and Mg in the extracts were determined by atomic absorption spectrophotometry, while a flame photometer was used to determine the contents of exchangeable K and Na as described by Rowell (1994).

Table 1: Laboratory analyzed data result

Species	Parameter pH	**OC (%)**	**TN (%)**	**C/N**	Na (meq/100g)	K (meq/100g)	Ca (meq/100g)	Mg (meq/100g)	years
Eissenia fetide	7.23	15.362	2.805	5.477	3.5012	18.8429	30.3972	33.3128	1st year
Eissenia fetide	7.07	17.948	2.277	7.882	2.3896	25.9035	25.1520	31.2793	2nd year
Eissenia fetide	7.78		2.669	7.357	3.6504	70.1480	31.0942	41.6489	3rd year

RESULT AND DISCUSSION

Analysis of variance for two factors randomized complete block design (Table 2) revealed highly significant difference ($P < 0.001$) due to the main effects of the levels of N rates for the means of red dry fruit weight, red fresh fruit weight and marketable yield. However, the interaction due to N rates × time of application of vermicompost was not a significant difference for the red dry fruit weight, red fresh fruit weight and marketable yield parameters. The highest red fresh marketable yield (2516.8 kg), red fresh fruit weight (2853.3 kg) and red dry fruit weight (1552.9

kg) were recorded under the applications of 150% of the recommended N from vermicompost, while the least red fresh marketable yield (1324.9 kg), red fresh fruit weight (1324.9 kg) and red dry fruit weight (657.6 kg) were recorded from the plot that received the full dose from inorganic N plants. However, the yield values obtained with 100% of the recommended N from vermicompost showed statistically similar values with 150% of the recommended N from vermicompost. This means that vermicompost has the potential to be used as a suitable source of nutrients for organic pepper growers.In conformity with the results obtained from this study, plant growth and development may be retarded significantly if any of the nutrient elements is less than its threshold value in the soil or not adequately balanced with other nutrient elements (Landon, 1991). Thus, the results indicated that vermicompost fertiliser application has enhanced the maize vegetative growth.

Table1. The effect of verm compost rates and time of application on red dry fruit weight, red fresh fruit weight and marketable yield of hot pepper.

Source of variation	Red dry fruit weight kg/ha	Red fresh fruit weight kg/ha	Red fresh Marketable yield kg/ha
N rates			
Full dose from inorganic N	657.6	1324.9	1324.9
50% of the RN from vermicompost	1115.8bc	1993.3c	1934.4b
75% of the RN fr om vermicompost	1068.1c	2246.5bc	1713.1b
100% of the RN from vermicompost	1472.7ab	2623.1ab	2320.5a
150% of the RN from vermicompost	1552.9a	2853.3a	2516.8a
LSD	1.7**	4.2***	3.7***
Time of application			
At planting	1521.5	2493	2207.2
20 days before planting	1430.5	2433	2013.9
30 days before planting	1306.6	2357	2142.4
LSD	-	-	-
CV%	24.59%	25.8%	26.2%

The maximum and significantly highest red dry fruit weight (1187 kg/ha), red fresh fruit weight (2853.3 kg/ha) and marketable yield (2516.8 kg/ha) were obtained from plots that received 150% of the recommended N from vermicompost. However, this treatment was statistically similar to 100% of the RN from vermicompost.On the other hand, the time of application had a non-significant ($p > 0.05$) difference on red dry fruit weight, red fresh fruit weight and marketable yield, while the highest was obtained from the application time at planting.

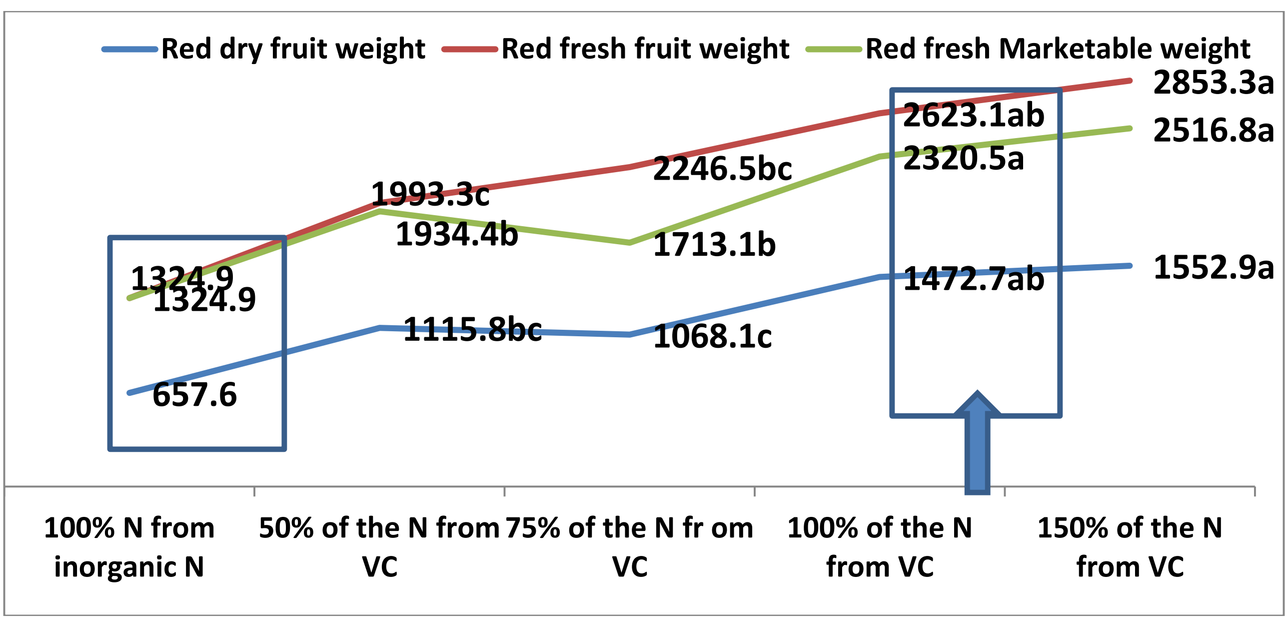

Figure1. Effect of year on fruit dry weight and marketable yield of hot pepper at Asossa district.

Similar to the previous year had a significant ($p < 0.001$) influence on pod per plant and plant height of hot pepper (Table 2). The highest mean number of pod per plant (18.15) and plant height (**59.9 cm**) were obtained during second year (2019). However the year had non-significant ($p>0.05$) difference on unmarketable yield (Table 3). Analysis of variance for two factors randomized complete block design (Table 2) revealed non- significant difference ($P >0.05$) due to the main effects of N rates and time application of vermcompost for the means of plant height and unmarketable yield.

Table 3. The effect of verm compost rates and time of application on unmarketable yield, number of pod per plants and plant height of hot pepper.

Source of variation	Un Marketable yield kg/ha	Plant height cm
Year		
2018	**239.1**	**53.87b**
2019	**109.9**	**59.9a**
LSD	**-**	**3.0*****
N rates		
Full dose from inorganic N	**96.6**	**53.5**
50% of the RN from vermicompost	**180.8**	**56.1**
75% of the RN from vermicompost	**192.3**	**55.5**
100% of the RN from vermicompost	**178.2**	**57.3**
150% of the RN from vermicompost	**146.6**	**58.3**
LSD	**-**	**-**
Time of application		
At planting	**159.2**	**57.1**
20 days before planting	**202.5**	**56.9**
30 days before planting	**161.8**	**56.4**
LSD	**-**	**-**
CV%	**22.93%**	**11.6%**

The interaction effect due to vermicompost rates and time of application was a highly ($p<0.01$) significant difference for the number of pods per plant.The maximum and significantly highest number of pods per plant (23.02) was obtained from the interaction effect of 75% of the recommended N from vermicompost with zero time of application (at planting application of vermicompost). However, statistical analysis indicated that there is no significant difference between 100% of the recommended N from vermicompost with 20 days of application before planting, 150% of the recommended N from vermicompost with zero time of application and 150% of the recommended N from vermicompost with 20 days before sowing.

Table 4. Interaction Effect of verm-compost rates and time of application on No of pod per plant of hot pepper

Rate of verm compost	**Time of application**		
	At planting	20 days before planting	35 days before planting
50% of the RN from vermicompost	14.86de	12.69e	17.12bcd
75% of the RN from vermicompost	18.46bcd	17.89bcd	8.0 f
100% of the RN from vermicompost	23.02a	19.23abc	15.6cde
175% of the RN from vermicompost	22.97a	20.0ab	11.8 ef

Means followed by the same letter within a column or row are not significantly different at 5% level of significance; LSD (1%) = 4.3 to compare verm-compost x year interaction;**= indicates significant difference at 1% level of significance; and CV (%) = 22.22.

There was a significant ($P < 0.01$) interaction of year × verm-compost rates on red dry fruit weight. The significant year and verm-compost rates interaction showed that the verm-compost produced higher red dry fruit weight at all verm-compost rates in 2019 than 2018. The highest red dry fruit weight (1552.9 kg/ha), were obtained during second year (2019).

Table 5. Interaction Effect of verm-compost rates and year on red dry fruit weight of hot pepper

Rate of verm compost	Year	
	Year one	Year two
50% of the RN from vermicompost	865.3cd	1115.8b
75% of the RN from vermicompost	734.9d	1068.1bc
100% of the RN from vermicompost	763.3d	1472.7a
175% of the RN from vermicompost	821.4d	1552.9a

Means followed by the same letter within a column or row are not significantly different at 5% level of significance; LSD (0.1%) = 2.4 to compare verm-compost x year interaction;***= indicates significant difference at 0.1% level of significance; and CV (%) = 24.59

Red dry fruit weight was the lowest (734.9 kg/ha) in 2018 when 75% of the RN from vermicompost fertilizer was applied (Table 5).The highest red dry fruit weight (1552.9 kg ha^{-1}) was obtained from plot that received maximum verm-compost (175% of the RN from vermicompost) during 2019 growing season, however statically analysis indicate that there were non-significant from plot that received 100% of the RN from verm-compost during 2019 growing season.

100% of recommended nitrogen from verm-compost increased the soil OC, OM and pH by 12%, 11.4% and 5.3% over 100% recommended N from inorganic fertilizer respectively with in one year. The pH value of the studied soils after harvesting showed regular increase with rates of the verm-compost (Figure1). The soil reaction (pH) varied from 5.25 to 5.53 in full dose from inorganic N and 100% of recommended N from verm-compost respectively. EthioSIS (2014), classified pH values into five classes, strongly acidic < 5.5, moderately acidic 5.51 - 6.5, neutral 6.6 - 7.3, moderately alkaline 7.3 - 8.4 and strongly alkaline > 8.4. The soils in the study area had 5.25 (strongly acid) to 5.53 (moderately acidic) in the plot received full dose N from inorganic and plot received full dose from verm-compost respectively (Figure 1).

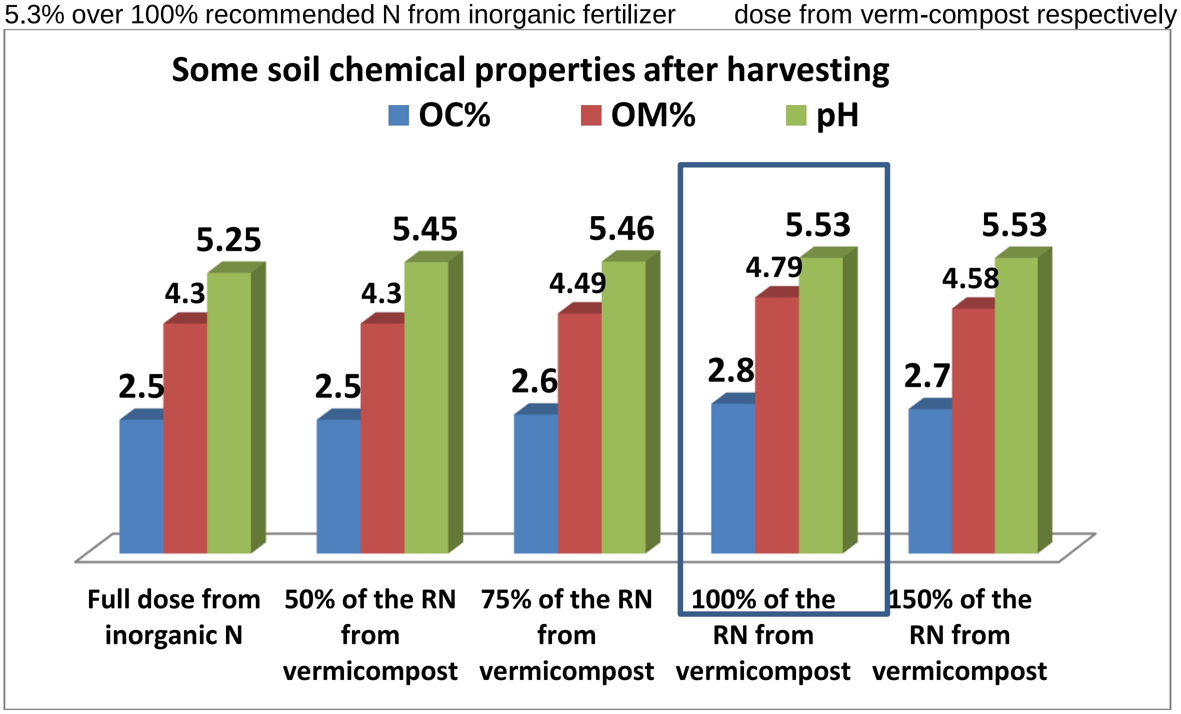

Figure 2. Effect of Verm-compost rates soil chemical properties.

According to Landon (1991), Soil pH value below 5.5 could be an indication of presence of appreciable amount of exchangeable acidity and exchangeable Al^{+3}, and removal of exchangeable cations, such as calcium and magnesium. The same as the organic carbon and organic matter value of the studied area showed regular increase with nitrogen source and rates of the soil after harvesting (Figure 2). The plot treated with full dose of inorganic N had lower organic carbon (2.5) and organic matter (4.3) content than the plot received full dose of organic N might be attributed to verm-compost addition from microbial and fertilizer supply that increased yield and the high cation exchangeable capacity of soil. These levels of soil pH could further indicate that phosphorus availability would be lowered through the binding effects of Al and Fe. Time of verm-compost application influence the soil chemical properties in some degree. zero time of application (application of verm-compost at time of planting) increased in some degree of the soil OC% OM%, pH and total nitrogen than 20 days and 35 days after planting or sowing application of verm-compost. This indicated that the nitrogen which present in verm-compos is readily available form and it's available for the crop as soon incorporated to the soil.

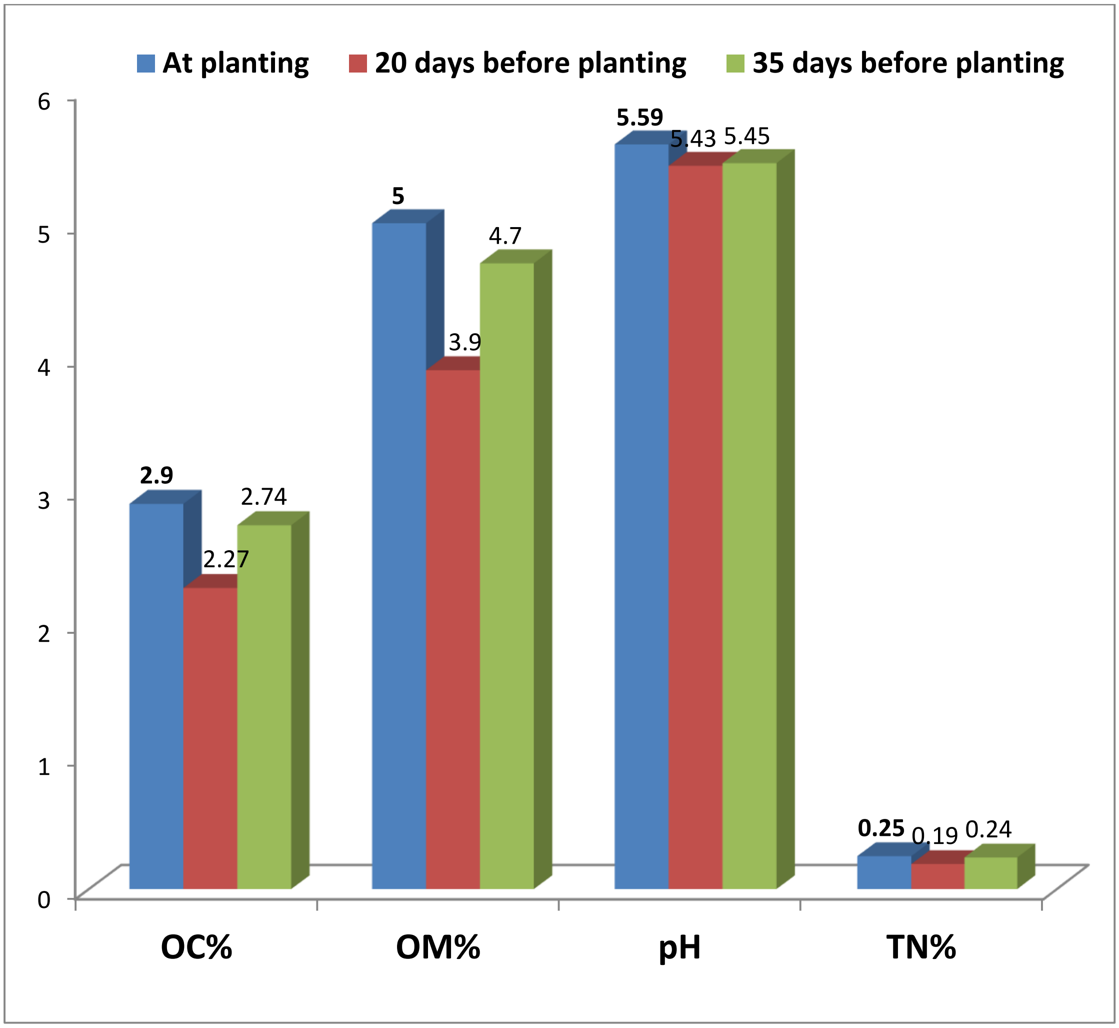

Figure 3. Effect of Verm-compost period of application on soil chemical properties.

Summary and recommendation

In recent years, crop productivity in Ethiopia in general and in the Benshal-gul Gumuz region in particular has shown a declining trend, in spite of the best use of improved varieties. The most possible causes of this decline are soil fertility depletion and the continuous use of the traditional fertiliser, which has a limited number of essential plant nutrients. In addition, due to high rainfall, soil erosion is a severe problem in sloping areas where vegetative cover is very low. Therefore, the present research was focused on studying the effect of vermicompost rates and its time of application on the yield and soil fertility status of hot pepper. The present study was conducted in Benishangul-Gumuz Regional State, at the Asossa Agricultural Research Centre station in the 2018 to 2020 main cropping season under rainfedfield conditions. Analysis of variance revealed a highly significant difference (P < 0.001) due to the main effects of the levels of vermicompost rates for the means of red dry fruit weight, red fresh fruit weight and marketable yield.The highest Red fresh marketable yield (2516.8 kg), Red fresh fruit weight (2853.3 kg) and Red dry fruit weight (1552.9 kg) were recorded under the applications of 150% of the recommended N from vermicompost and were statistically on par with 100% of the recommended N from vermicompost, while the least Red fresh marketable yield (1324.9 kg), Red fresh fruit weight (1324.9 kg) and Red dry fruit weight (657.6 kg) were recorded from the plot that received the full dose from inorganic N plants.From the perspective of red dry fruit weight, red fresh fruit weight and marketable yield of hot pepper and soil chemical properties after harvesting. 100% of vermicompost at the time of planting or sowing was considered the best recommendation of nitrogen rate, source and time for hot pepper in the Asossa district.

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