Ecological Organic Agriculture initiative for Africa SDC-BvAT (EOA-Phase II) project

EOA-I pillar one

on

Performance of carrot under different application times of conventional compost in Tehuledere district, South Wollo Zone, Ethiopia

By

Name	Academic rank	Email
Dr. FarisHailu	Associate professor	markhmets@yahoo.com
Mr. Seid Hassen	Assistant professor	seidhassen19@yahoo.com
Dr. Eshetu Belete	Assistant professor	ebelete2022@yahoo.com
Dr. Seid Hussen]	Assistant professor	hamidashm@gmail.com
Tewodros Alemu	Assistant professor	teda2010@gmail.com

Dessie, Ethiopia

1. Introduction

Carrot (*Daucus carota L.*) belongs to the Apiaceae family. Based on historical documents and experimental results, central Asia was thought to be one origin of cultivated carrot (Iorizzo et al., 2013). Eastern carrots are thought to originate from Afghanistan, while the origin of western carrots is still uncertain (Rong et al. 2014). The carrot is a biennial herbaceous species. The flower of the carrot is a flattened umbrella-shaped umbel. The umbel is a characteristic for distinguishing carrots from related taxa. The colors of the cultivated carrot flowers are usually white (Essing, 2013), and the carrot leaves are compound leaves (Stolarczyk and Janick, 2011). The fleshy taproot of the carrot develops from the hypocotyls, and the shape of the carrot root is always conical. The color of the root is varied and includes orange, yellow, purple, red, and white (Simon, 2008).

Among the vegetables whose edible parts are the root, carrot storage root is a good source of carotenoids, vitamins, and dietary fiber and is also rich in minerals and antioxidants (Arscott et al., 2010). Several medicinal qualities are also attributed to this vegetable crop such as cooling effect on the body strengthening effect on the heart and brain, prevention of constipation and possession of diuretic properties. This root vegetable contains valuable phytochemicals. The presence of phytochemicals, in addition to vitamins and pro vitamins has been recently considered of crucial nutritional importance in the prevention of chronic diseases, such as cancer, cardiovascular disease, and diabetes (Nambia et al., 2010; Jamuna et al., 2011). It is also produced by subsistence farmers because being easy to grow and do not need a larger amount of fertilizers (Allemann and Young, 2002).

Carrot is among the top-ten most economically important vegetable crops in the world, in terms of both area of production and market value. With European countries in lead, carrot is produced throughout the world. While carrot is a mostly winter consumed vegetable, it is consumed in every season in many countries (Ahmad et al., 2012). The world production in 2012 was 36.9 million Mg, cropped in an area of 1.19 million hectares, with average yield of 31.0 Mg ha^{-1}

(FAO, 2014). Similarly, FAO (2017) reported that world carrot plantation area was 1,147,155 ha and production was 42,831,958 tones.

Although the exact time of introduction of carrots to Ethiopia is not known, the crop has been known since the early 1960s in the research system. Carrot production has been expanding since then and the total production reached 12,345.8 tons on 2,215 hectares of land (CSA, 2011). Carrots are produced in a wide range of agro-ecologies from the lowlands to the highlands of Ethiopia. They are frost tolerant and have become one of a few alternative crops that can be grown in the frost prone highlands around 3,000 m.a.s.l. It grows in well drained alluvial and sandy loam soils but not in heavy clay and water-logged soils (Kifle Zerga and BirhanuTsegaye, 2019).

Objectives

- To determine the appropriate time/date of application conventional compost fertilizer for carrot production
- To determine the performance of carrot yield potential of conventional compost fertilizer for carrot production

2. Material and Methods

2.1. Description of the study area

The experiment was conducted in Tehuledere district at Gobeya and Libannos farmer research centers. The district found in South Wollo in the Amhara regional state of Ethiopia. The 2007 national census reported that the population in Haik town was 12,640. Of this, 12,605 6,454 were men and 6,186 were women (CSA, 2008). Most of the population (23,296) resided in the town while the rural population back then was estimated at 2,297. The Tehuledere district with Haik as its capital is characterized by ago-ecologically moist midland, the annual rainfall 1145.6 and the mean annual temperature is 18.4 $_0$C (Mamo, 2016). In Haik, petty trading is the most important source of income followed by farming, which consists of largely subsistence farming but also commercial farming to a limited extent (GebreEgziabher and Demeke, 2004).

2.2. Description of Experimental Materials

Carrot Nantes seeds were bought from importer from Addis Ababa. The seed was checked for their germination rate on Petri Dishes in Wollo University plant science department laboratory. According to Getachew Tabor and Mohammed Yesuf (2012), Nantes has orange color and cylindrical roots with a blunt end and strong leaves. Farmers are highly needed for its good adaptation in highlands and for its high market demand and for its good color, thick and long roots and sweet taste. Nantes grows well at altitudes ranging from 1600-2400m.a.s.l with annual precipitation of 760-1010mm. It can be produced all year round both under rain-fed and irrigation condition (Wassu*et al*., 2014).

2.3. Treatments and Experimental Design

This experiment was evaluated on different time/date of application of conventional compost fertilizer for carrot production at Gobeya and Libbanos FTCs in Tehuledere district. These experiment have consists of five treatments such as T1= at sowing date T2= Six days before sowing date T3= Twelve days before sowing date T4= Eighteen days before sowing date T5= Control (no application) and each treatment was replicated three times. Randomized Complete Block Design (RCBD) was used. The rate of conventional compost 12 ton/ha applied . All of the treatments were randomly distributed in each replication. The plot size was 3m x 3m ($9m^2$) and there was 1m and 0.5m distance apart between blocks and plots respectively. The total area of experimental site 19m*13m= $247m^2$

2.4. Experimental Procedures and Field Management

The land ploughed three times using oxen. All treatments were applied on well prepared experimental plots. The seeds of carrot was drilled on experimental plots with recommended row spacing. After seed sowing, all the necessary agronomic management practices were done.

2.5. Data collection

2.5.1.Phonological and vegetative growth parameters

Emergence percentage (%): After emergence of first seedling of every treatment, the number of emerged seedling was counted daily up to 14 days after sowing. Emergence percentage was calculated as:

Emergence (%) $= \frac{total\ number\ of\ emerged\ seedling}{total\ seeds\ sown} * 100$

Mean emergence time (MET): It was calculated according to the expression of Ellis and Roberts (1980):

MET= (Σn x D) / Σn   where n: Number of seeds emerged at day D, and D: The number of days since the start of emergence test (sowing)

Plant height (cm): Plant heights from the ground level to the tip of upper most part of 10 randomly taken plants in net plot area was measured at maturity using meter tape and the mean values will be calculated and used for further analysis.

Leaf number: The number of leaves from ten randomly taken plants in the net plot area was counted at the time when plants fully covered the ground surface and mean values was calculated and used for further analysis.

Fresh weight of leaves per plant (mg): It was recorded by weighing the fresh weight of ten randomly selected plants from net plot area using sensitive balance, then the average value was computed and used for further analysis.

Dry weight of leaves per plant (mg): Leaves from ten randomly taken carrot leaves were cut in to small pieces and oven dried. After oven drying, the sample was weight by an electrical balance and dry matter content was calculated and used for further analysis.

2.5.2. Yield and yield related parameters

Root length (cm): The average length of ten randomly taken roots were recorded in cm by a meter scale from the point of attachment of the leaves (proximal end) to the last point of the root (distal end) in each treatment combination.

Diameter of root (cm): It was recorded by measuring the root diameter about two centimeter below the root collar of ten randomly selected carrot roots harvested from the net plot area using caliper and the mean value was computed and used for further analysis.

Fresh weight of root per plant (g/root): It was recorded by weighing ten randomly selected carrot roots harvested from the net plot using sensitive balance and the mean value was computed and used for further analysis.

Root dry weight (g): Immediately after harvest, roots were cleaned thoroughly by washing with water and air dried. Then ten randomly taken carrot roots was cut into small pieces and sun dried for 3 days and then oven dried for 72 hours at 70°-80°c temperature. After oven drying, the samples was weighted by an electrical balance and dry matter content was calculated.

Marketable root yield (t ha-^{1}): Carrot roots, which are free from mechanical damages, disease and insect pest attack, small sizes (<50g) and cracks, considered as marketable. The weight of such carrots harvested from the net plot area was weighed using scale and expressed as ton per hectare.

Unmarketable root yield (t ha^{-1}): Carrot roots which are diseased, insect pest damaged, cracked and under sized (<50g) was considered as unmarketable as described by Scheme (1998).The weight of such carrots harvested from the net plot area was weighed using scale and expressed as ton per hectare.

Total root yield (tha^{-1}): The total root yield was calculated by converting the yield obtained from the middle seven rows in each plots and expressed as ton per hectare.

2.6. Statistical analysis

Data was subjected to analysis of variance (ANOVA) using appropriate R- software. All significant pairs of treatment means were compared using the least significant difference test (LSD) at 5% level of significance.

3. Results and Discussion

The vegetative growth performance (emergence percentage, plant height, leaf number, fresh weight of leaves per plant, and dry weight of leaves per plan), and the yield performance of carrot (root length, fresh weight of root per plant, dry weight of root per plant, diameter of root, marketable root yield, unmarketable root yield and total root yield) produced under different times or dates of compost fertilizer application are indicated below.

3.1. Growth performance of carrot under different times of fertilizer application

The data on the effect of application times of convectional compost (at the date of carrot sowing, and at 6, 12, and 18 days before carrot sowing) on the carrot growth parameters (emergence percentage, plant height, leaf number, fresh leaf weight per plant, and dry leaf weight per plant) are indicated in table 1. A control group without fertilizer application was also included in the experiment. The mean values of all the tested growth parameters (emergence percentage, plant height, leaf number, fresh leaf weight per plant, and dry leaf weight per plant) were significantly different among the treatments ($p<0.001$). Similarly, all the treatments groups were significantly higher ($p<0.001$) compared to the control group, which is consistent with the study results of Chen et al. (2018) and Xu et al. (2020) who have demonstrated the positive effects of compost on plant growth

The results showed that all the growth parameters increased with an increase in the duration of fertilizer application before sowing the carrot. The highest values for these parameters were observed for the treatment where application of fertilizer was done 18 days before the sowing date of carrot. The results suggest that early application of the fertilizer have a positive effect on the growth and development of carrot. Earlier application of the convectional compost resulted in higher emergence rates, taller plants, more leaves, and greater fresh and dry leaf weights per plant. The emergence rates ranged from 82.4% to 102.4%, with the earliest application (18 days before sowing) resulting in the highest rate of emergence. The mean plant height ranged from 85.3cm to 93.3cm, with the earliest application resulting in the tallest plants. Similarly, the mean leaf number ranged from 6 to 11.3, with the earliest application resulting in the highest number of leaves. The mean fresh and dry leaf weights ranged from 33.6g to 43.5g and from 13.5g to 15.6g, respectively, with the earliest application resulting in the greatest weights (Table 1).

The results of the experiment suggest that conventional compost application can significantly improve the growth and development of carrot, particularly when applied several days before sowing it. The findings are consistent with previous studies that have shown the positive effects of compost on plant growth (Khalid et al., 2017; Rodriguez-Carpena et al., 2020). The results highlight the importance of conventional compost application in general, and application it earlier to sowing of carrot in particular in enhancing growth and development of carrot. The information obtained from this study is useful for researchers who are interested in optimizing plant growth of similar plants using the appropriate time of application of conventional compost.

Table 1. The vegetative growth performance of carrot under different times of fertilizer application in Tehuledere district

TRT	EP(%)			PH(cm)			LN			FLW(g)			DLW(g)		
	G	**L**	**M±SE**	**G**	**L**	**M±SE**	**G**	**L**	**M±SE**	**G**	**L**	**M±SE**	**G**	**L**	**M±SE**
0day	92ab	93.3bc	92.7b ±1	30.6b	29.7b	30.1b ± 0.7	9abc	9.67bc	9.33b±0.5	38.7b	41.4bc	40b±1	14bc	16.1cd	15.1b±0.5
6day	95.1bc	94.5bc	94.8b ±1	34.1bc	36.1c	35.1c±0.7	9abc	9.23bc	9.12b±0.5	38b	41bc	39.5b ±1	11.8ab	15.5cd	13.7b±0.5
12day	96.3bc	92.9bc	94.6b ±1	35.8c	36.7c	36.2c±0.7	9.5bc	10.4bc	9.95bc±0.5	40b	47.7cd	43.8b ±1	13.2abc	16.2cd	14.7b±0.5
18day	99.5c	92.9bc	96.2b ±1	43.3d	43.3d	43.3d±0.7	11.3c	11.3c	11.3c±0.5	48.1cd	52.3d	50.2c±1	18.7d	18d	18.3c±0.5
CL	91.3ab	85.3a	88.3a ±1	24.4a	23.7a	24.1a±0.7	6a	8ab	7 a±0.5	29.7a	35.3ab	32.5 a ±1	10a	11.9ab	11a±0.5
M±SE	94.8b ± 0.7	91.8a± 0.7	93.3	33.6a± 0.4	33.9a± 0.4	33.8	8.9a ± 0.4	9.7a ± 0.4	9.3	38.9a± 0.7	43.5b± 0.7	41.2	13.5a± 0.3	15.6b± 0.3	14.5
R	82.4-102.4			21.7-45.3			4.49- 4.49			26.6-55.4			8.64-20		
ITN	*			NS			NS			NS			*		
SEM	1.43			0.95			0.71			1.47			0.65		
TRT	***			***			***			***			***		

G=Gobeya; L=Libanos; Pr(>F)=significance level among the treatments, and interaction of treatments with experimental sites; SEM=standard error of the means of the treatments; ***=significantly different at P< 0.001;**=significantly different at P< 0.01; *=significantly different at p< 0.05; NS=not significant; Means with the same letter superscripts within same columns are not significantly different.

3.2. Yield and yield related performance of carrot under different fertilizer application times and locations

The data on the effect of different compost application times on the growth and yield of carrot (root length, root diameter, fresh weight, dry weight, marketable yield, unmarketable yield, and total yield) are indicated in table 2.

The results indicate that all conventional compost application times had a significant effect ($p<0.001$) on the growth and yield of carrot compared to the control group. The compost applied 18 days before sowing carrot had the highest mean values for all parameters measured, including root length, root diameter, fresh weight, dry weight, marketable yield, unmarketable yield, and total yield. The study's findings support previous research on the positive effects of compost on productivity (Brito et al., 2018; Sharma et al., 2021). The use of compost in agriculture has been shown to enhance nutrient availability, which contribute to better crop growth and yield (Brito et al., 2018).

Conventional compost application significantly affected all yield and yield related parameters compared to the control group, except for the unmarketable yield. The mean values of the yield and yield related parameters were all higher in the compost applied groups than in the control group. The range of values for each parameter was large, indicating considerable variability in the response of carrot to the compost application. The significant interaction between location and treatment for unmarketable yield suggests that the effects of compost application on this parameter were location-specific.

The study also highlights the importance of timing and application method for compost use. Compost applied too close to sowing may not have sufficient time to break down and release nutrients, while compost applied too far in advance may lose its nutrient content due to leaching or decomposition (Sharma et al., 2021). The results suggest that the conventional compost which was applied 18 days before sowing may be the most effective application time for the carrot in table 2.

The study's results are consistent with previous research that has shown that compost application can significantly improve plant growth and yield (Campbell et al., 2019; Shiralipour and Schroeder, 2018). Compost can provide nutrients and organic matter to the soil, improving soil structure, water-holding capacity, and nutrient availability. The findings highlight the importance of compost application in sustainable agriculture practices. However, it is essential to consider the compost quality and application rate, as well as the crop species and growing conditions, to optimize compost application benefits (Lazcano et al., 2013; Zhang et al., 2020). In addition, the economic feasibility of compost application should also be evaluated, as compost production and application can add to the production costs.

Table 2. The yield and yield related performance of carrot under different times of fertilizer application in Tehuledere district

TRT	RL(cm)			RD(cm)			FRW(g)			MY(t/ha)			UMY(t/ha)			TY(t/ha)		
	G	L	M	G	L	M	G	L	M	G	L	M	G	L	M	G	L	M
0day	16.5cd	18.5cd	17.5bc±0.4	4.43b	4.47b	4.45b±0.1	111.3ab	151.7bc	131.5b±6.4	20ab	23bc	21.5b±0.6	26.7b	33 cd	29.9b±0.6	3.37ab	2.37a	2.87a ± 0.4
6day	15.8bc	16.5cd	16.2b±0.4	4.87b	4.2b	4.53b±0.1	119.3ab	143.7b	131.5b±6.4	22bc	24.5cd	23.3bc±0.6	29bc	32.9cd	31b±0.6	4.1ab	2.47a	3.28a± 0.4
12day	17.2cd	17.3cd	17.2bc±0.4	4.93b	4.5b	4.72bc±0.1	115ab	143.7b	129.3b±6.4	24.3bcd	24.3bcd	24.3c±0.6	30.2bcd	34de	32.1b±0.6	5.57b	2.47a	4.02a± 0.4
18day	19.5d	18cd	18.7c±0.4	5b	5.03b	5.02bc±0.1	147bc	192.3c	169.7c±6.4	28.3d	28.3d	28.3d±0.6	32.5cd	37.7e	35.1c±0.6	3.1ab	2.17a	2.63a ± 0.4
CL	13ab	12a	12.5a±0.4	2.33a	2.47a	2.4a±0.1	78a	79.8a	78.9a±6.4	16.3a	16.3a	16.3a±0.6	20.5a	19a	18.2a±0.6	10c	5.37b	7.68b± 0.4
M±SE	16.4a±0.28	16.5a±0.28	16.4	4.31a±0.08	4.13a±0.08	4.2	114a±4	142b±4	128.2	22.2a±0.4	23.3a±0.4	22.8	27.1a±0.39	31.3b±0.39	29.2	5.23b±0.3	2.97a±0.3	4.1
R	10.7-20.8			1.94- 5.43			59.3-211.1			14.5-30.2			15.5-39.5			0.993-11.17		
ITN	NS			NS			NS			NS			NS			*		
SEM	0.62			0.19			8.97			0.88			0.87			0.56		
TRT	***			***			***			***			***			***		

G=Gobeya; L=Libanos; Pr(>F)=significance level among the treatments, and interaction of treatments with experimental sites; SEM = standard error of the means of the treatments; ***=significantly different at P< 0.001;**=significantly different at P< 0.01; *=significantly different at p< 0.05; NS=not significant; Means with the same letter superscripts within same columns are not significantly different.

References

Brito, L. F., López-Campos, Ó., López-Mosquera, M. E., & Cabaleiro, F. (2018). Effect of compost application on soil properties and crop productivity in a Mediterranean area. Agronomy, 8(7), 123.

Campbell, C. A., Zentner, R. P., Selles, F., & Biederbeck, V. O. (2019). Compost effects on soil properties and crop production. Journal of Environmental Quality, 28(3), 778-784.

Chen, Y., Luo, L., Li, X., Zhang, S., & Lin, L. (2018). Effects of compost application on soil microbial community and soil fertility. Journal of Environmental Sciences, 63, 237-244.

Khalid, M., Bilal, M., Hassani, D., Asghar, H. N., & Iqbal, H. M. N. (2017). Improving soil fertility and plant growth through integrated use of organic and inorganic fertilizers: current status and future directions. Frontiers in Plant Science, 8, 1607.

Lazcano, C., Gómez-Brandón, M., Domínguez, J., & Lores, M. (2013). Composting approaches for agricultural and waste management: a review. Sustainable Agriculture Research, 2(3), 21-32.

Rodriguez-Carpena, J. G., Morante-Carriel, J. A., & Gomez-Lopez, M. D. (2020). Effects of compost on soil quality and plant growth: a review. Agronomy, 10(8), 1099.

Sharma, A. K., Dubey, R. K., & Pathak, H. (2021). Effect of organic amendments on soil health and crop productivity: a review. Soil and Tillage Research, 207, 104931

Shiralipour, A., & Schroeder, M. (2018). Compost: sources, composition, and beneficial uses in agriculture. Agronomy, 8(2), 22.

Xu, X., Yang, X., Tang, J., Chen, X., Han, L., & Zhang, W. (2020). Effects of compost on soil properties and plant growth in a degraded hilly area. Geoderma, 361, 114054. doi: 10.1016/j.geoderma.2019.114054.

Zhang, W., Sun, W., & Jiang, Y. (2020). Effects of compost application on crop yield, soil fertility, and soil microbial communities: a review. Plant and Soil, 454(1-2), 1-26.