

Effect of Different Rates of Compost Application on Growth Performance and Yield Components of Carrot (*Daucus carrota* L.) in Gurage Zone, Ethiopia

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Abstract

The research pertaining to the use of organics and bio fertilizers in vegetable crops particularly in carrot is very much limited. So far no research has been conducted to see the effect of compost fertilizer on growth performance and yield of carrot. Therefore, the goal of the present experiment was to evaluate the growth performance and yield component of carrot to different rates of compost application under supplemental irrigation condition. The experiment was conducted at demonstration site of horticulture department, College of Agriculture and Natural Resource, Wolkite University during 2017 cropping season. The experiment was laid out by using randomized complete block design (RCBD) with four treatments. The treatments consisted of four levels of compost application rates (0, 25, 50 and 75 tons ha⁻¹). Carrot variety known as ‘Nantes’ was used as experimental material. All recorded data were subjected to ANOVA in Randomized complete block Design and the analysis was performed by using statistical procedures from Gomez and Gomez text book. The analysis of variance indicated that most of the growth and yield component parameters (like plant height, leaf number, fresh weight and shoulder diameter) showed highly significant ($P < 0.01$) difference among treatments, whereas dry weight was significantly ($p < 0.05$) different. However, no significant difference was observed among treatments on the parameter Root Length. The finding of this study indicates that Statistically the highest plant height (29.16cm and 23.91cm) and fresh weight (23.48g and 15.20g) was recorded from compost application rates of 70ton/ha and 50 ton/ha, respectively. Similarly, the highest leaf number (15.16), dry weight (7.14g) and shoulder diameter (1.70cm) per plant was recorded from the maximum compost application rate (75ton/ha). However, no statistical difference was observed among treatments on parameter root length. Thus, from this result we can conclude that compost application at the rate of 75ton/ha can give the maximum record for growth parameters and yield components of carrot. Further to this we recommend the experiment to be conducted across location and year by incorporating additional compost level one or two level up together with inorganic fertilizers.

Keywords: Carrot, Compost, Growth

DOI: 10.7176/JAAS/54-03

Publication date: April 30th 2019

1. Introduction

The carrot (*Daucus carrota* L.) belongs to the family *Apiaceae*. The plant is a biennial but it growth as an annual crop. It belongs to the moderately hardy group of plants that are not particularly sensitive to winter cold and frost. It does best under cool condition and their seed also germinated quite well, though slowly, under cool condition. Crop development is much slower when temperature is higher (Moncrief *et al.*, 1991). Carrot is a root crop and is used as a vegetable for soups, stows, curries and pies; grated roots are used as salad. Tender roots are used for making pickles and halwa. Carrot juice is very popular and is the main source of carotene and is also used as coloring buffer in food preparation. Carrot leaves (tops) are also used in many countries as a source for extraction of leaf proteins, fodder and the preparation of poultry feed. Carrot root is an excellent source of carotene (1890 mg/100 g fresh weight) and precursor of vitamin A and fiber. Carrot was widely used by the ancients as a medicinal plant rather than for food. It is rich in carotene, a precursor of vitamin A, and contains appreciable quantities of thiamin and riboflavin. Carrots are primarily consumed flesh either alone or conjunction with other vegetables or in meat or fish dishes. It can be baked, boiled, steamed, fried and roasted with meat. Large quantity is also processed, either alone or mixtures with other vegetables, by canning, freezing and dehydrated (Warman, 2000).

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. Purple and black carrots are used for the preparation of beverage called ‘Kanjal’ which is very good appetizer. Although, this root crop has lot of potentialities and widely cultivated since long, yet its yield per acre remains very low and there is lot of need to increase the production potential of carrot (Allemann & Young, 2002).

Several attempts have been made to increase yield potential of root crops, but they are concerned with use of inorganic fertilizers which results in loss of soil fertility and soil health. On the other hand, the use of organic and bio fertilizers like FYM, compost, poultry manure and vermi composting is gaining more importance for getting higher yield and quality. Farm yard manure being bulky organic material, releases the soil compactness

and improves the aeration in addition to the supply of essential plant nutrients and organic matter and increase soil microbial establishment along with accumulation of excess humus content. Vermi-composting is rich in both macro and micro nutrients (Fritz, 2007).

Organic fertilizers improve soil tilth and structure, thereby allowing root development into deeper soil layers. This in turn promotes plant growth and increases yield. Although the use of organic fertilizers is one of the oldest methods in crop production used by farmers, especially where these organic sources are in abundance, it should be remembered that the use of fresh manure is not recommended due to its burning effects on plants, especially young seedlings (Oelhaf, 1978; Taiz&Zeiger, 1991; Lampkin, 2000, FSSA, 2003). Among the essential elements needed by crops, nitrogen is the element that limits growth the most. Nitrogen deficiency is also more likely to occur where immature compost is used since microbes use nitrogen during the breakdown of organic material, which is supposed to be used by the plants (Oelhaf, 1978; Taiz & Zeiger, 1991; Lampkin, 2000, FSSA, 2003).

Organic fertilizers are made from materials derived from plant and animal residues. The positive effect of most commonly used organic fertilizers on crop production and soil fertility are dependent on the quality, rate, timing and method of application. The amount of nutrients and the type of elements available from the specific organic fertilizer used is again dependent on the age, origin as well as climatic conditions such as temperature and rainfall (Grubinger, 1999; Lampkin, 2000; FSSA, 2003).

Organic fertilizers add humus to the soil and this has the ability to hold positively charged ions (cations) and negatively charged ions (anions) and make them available to the plants through the process of exchange capacity. Humus added by organic fertilizers adsorbs large quantities of water and makes it available to plants during drought. This feature as well as the capacity to hold nutrients is important for sandy soils which retain very few nutrients and water (Scholl & Nieuwenhuis, 2004). Organic fertilizers enrich the soil with organic matter, which improves soil structure or workability (soil tilth), making the soil easier to plough (sand and clay soils). Since clay soil has few macro-pores, it inhibits the transport of water and oxygen to plant roots leading to suffocation, plant stress (directly) or susceptibility of plants to diseases and pests (indirectly). Therefore, the application of organic fertilizers assists structuring of clay soil to open and admit air penetration to roots and water drainage, both conditions necessary for satisfactory plant growth (Eimhoit *et al.*, 2005). Organic matter enhances root growth and nutrient uptake resulting in higher yields. Through composting methods, diseases, pests and weed seeds are destroyed by high temperature in the compost heap (Scholl & Nieuwenhuis, 2004).

However, improper use of organic fertilizers can cause nitrates to accumulate in ground water, and also in crops if they are taken up by the plant roots (Oelhaf, 1978; Gontcharenko, 1994). Improper processed organic fertilizers may contain pathogens from plant or animal matter that are harmful to humans or plants. Compost derived from municipal waste and sewage may contain toxic elements such as lead, cadmium and arsenic that contaminate food and reduce quality.

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 3000 masl. They grow in well drained alluvial and sandy loam soils but not in heavy clay and water-logged soils. Carrots are usually grown on small plots in the backyards of town and peri-urban dwellers for family consumption; however, some farmers grow carrots on up to 0.25 to 1 ha as a means of income (Simretkifle-Iyesus, 1994).

Carrots can be grown throughout the year if rain and irrigation water is available, but different factor affects the growth and developments of carrot productions such as weed, climate disease and fertilizer application. Among those factors, fertilizer application is one of the major critical problems in production of carrot. The needs for fertilizer application depend on mainly on soil condition. Since the price of inorganic fertilizer is very expensive to purchase and use it; farmers fail to produce high quality and yield of carrot crop. The rising cost of fertilizers has compelled farmers to look for other alternatives to sustain cultivation. Application of compost which is relatively more environmentally friendly could be the best alternative. However, the use of compost as soil amendment is not common in Ethiopia; so, this experiment will be conducted to help farmers in exploring compost for improvement of soil fertility and to reduce overdependence on only inorganic fertilizer (Simretkifle-Iyesus, 1994).

In Gurage Zone, from a total of 37,190ha of land which is cultivated by vegetables, 500ha is occupied by carrot. The annual production of carrot within the zone reached to 12630ton in the year 2012, according to survey data (Bezabih *et al.*, 2015). Bezabih *et al.*, 2015 surveyed data indicated that the major biotic and abiotic factors that mainly constraint carrot production are: low moisture stress, diseases and market problem. Farmers in the study area use organic fertilizers like compost, but they are not aware of the appropriate compost fertilizer application rate. Thus, this study was conducted with the following objectives.

❖ **General objective:**

- ✓ To examine the effect of different rates of compost application on growth performance and yield component of carrot.

❖ **Specific objective:**

- ✓ To determine the optimum compost application rate that increases the growth performance and yield components of carrot.

2. Materials and Methods

2.1. Description of the study area

The experiment was conducted at Wolkite University College of Agriculture and Natural Resource, practical field site in 2009E.C in the off season irrigation. The area is located south west of Addis Ababa with 170 km. The latitude 8°11'60.0"N and longitude 37° 47'60.0". Its elevation was between 1900 to 3000m. The annual rainfall of the area was 1294mm and the annual average temperature was 20.5° c while the maximum and minimum recorded temperature being 24°c and 14°c respectively

2.2. Treatments and experimental design

Four different levels of compost application rates (0 ton/ha, 25ton/ha, 50ton/ha and 75 ton/ha) were used as experimental treatments. Randomized complete block design (RCBD) was used with single factor and each treatment was replicated three times. All the treatments were randomly distributed in each replication. Plot size was 1m x 1m (1m² area). 1m and 0.5m distance was left between blocks and plots, respectively. Total area of experimental site was 39m². each plot consist of six rows and each row had seven plants, and a total of 42 plants per plot. Space of 16cm and 13.5cm was left between rows and between plants.

2.3. Experimental Procedures and field managements

The land was first ploughed by tractor then after leveled and raised beds of 1mx 1m were made by hand. Different rates of compost fertilizer was applied on well prepared experimental plots according to the treatments about three weeks before seed sowing. Seed of carrot variety known as "nantes" was drilled to the experimental plots at row spacing of 16cm. After seed sowing all the necessary management practices like watering, mulching and weeding was performed on time. when the sown seeds come to germination, thinning activity was made by hand to maintain space of 13.5cm between plants. All field management practices, like watering was applied twice a day, weeding, and cultivation was made whenever required to keep the plants free from weed competition and to maintain their healthy growth. All data were recorded before the plant comes to physiological maturity stage, this was because of shortage of time to reach to physiological maturity stage of the crop which is the appropriate stage for data collection.

2.4. Data collected

Data were collected on growth and yield component parameters.

2.4.1. Growth parameters

Plant Height: - Plant height was recorded by measuring the height of four plants taken from the middle rows using a ruler starting from the base of the plant to the most tip part.

Number of leaves: -The leaf number was taken every week by counting the number of leaves from each tagged plant.

2.4.2. Yield Components

Average root fresh mass (g/plant): was recorded by measuring the fresh weight of four carrot root by using a balance and calculate the average.

Average root dry mass (g/plant): was determined by drying carrot root of four plants from each plot in an oven drier at temperature of 75°C for a period of 48 hours and measuring the weight of the dried carrot roots by using a balance and calculate the average.

Shoulder diameter (cm): was determined by measuring the diameter of the root shoulder (2cm down from the top) of four plants by using a ruler and calculate the average.

Root length (cm): was determined by measuring the average root length of four plants from the shoulder to the tip part of the root by using a ruler.

2.5. Data Analysis

Data obtained from different growth and yield component parameters was analyzed by using statistical text book (Gomez and Gomez, 1984). All the collected data were subjected to analysis of variance (ANOVA). Treatment means were compared at 5% level of significance.

3. Results and Discussion

3.1. Growth parameters

3.1.1. Plant height

The analysis of variance revealed that there is highly significant ($p < 0.01$) difference among treatments for the parameter plant height (Appendix Table 2).

The highest plant height (29.16cm) was recorded from the treatment 75ton/ha compost application rate, whereas the lowest plant height (17.25cm) was recorded from treatment 0ton/ha compost application rate (Table 1). However, 50ton/ha and 75ton/ha compost application rates were not significantly different. Similarly, treatments 0ton/ha and 25ton/ha are in statistical parity. Thus, from this we can conclude that application of 75ton/ha compost will give the maximum plant height, whereas no compost application (0ton/ha) of compost gave the least plant height. This result is in line with (Levy and Taylor, 2003; Barker A.V, 2004; Walker and Bernal, 2004). The reason for maximum height of plants at maximum application of compost is due to the high fertility level of the soil, which can feed the roots of plants with adequate nutrient and thereby contribute for their increase in height.

3.1.2. Leaf number

The analysis variance showed that there is highly significant ($p < 0.01$) difference among treatments for the parameter of leaf number (Appendix Table 1).

The highest leaf number (15.16) was recorded from treatment 75ton/ha compost application rate, whereas the lowest plant height (8.25) was recorded from treatment 0ton/ha compost application rate (See table 1). The treatment 75ton/ha compost application rate was significantly different from the rest of the treatments. However, treatments 0ton/ha, 25ton/ha and 50ton/ha were not significantly different. from this we can conclude that application of 75ton/ha compost can gave the maximum number of leaf per plant. The reason for this might be due to the increased fertility of the soil in which the soil can provide the necessary nutrients for the increased vegetative growth of the carrot plant, which thereby leads to an increase in leaf number. This result is in agreement with other scholars who reported that compost application improved vegetative growth of carrot plant (Dawuda *et al.*, 2011).

Table 1. Treatment means for growth parameters at Wolkite University, 2017 cropping season

Treatment (ton/ha)	Plant height (cm)	Leaf number
	Mean	Mean
0	17.25c	8.25b
25	20.25bc	9.00b
50	23.91b	9.50b
75	29.16a	15.16a
LSD (at 5%)	4.07	2.69
CV (%)	8.99	13.26

Note that means with same letter are not statistically significant different, LSD= least significant difference, CV=coefficient of variation

3.2. Yield components

3.2.1. Root length

The analysis of variance indicated that there is no statistically significant difference between treatments for the parameter root length (Appendix Table 3). This result is in agreement with (Dawuda *et al.*, 2011).

3.2.3. Fresh weight

As shown in Appendix Table 4 the application of compost on carrot showed a highly significant ($p < 0.01$) difference among treatments for the parameter fresh weight.

Statistically, the highest fresh weight (23.48g/plant and 15.20g/plant) was obtained from compost application rates of 75ton/ha and 50ton/ha, respectively. However, the lowest fresh weight (6 g/plant and 9.86 g/plant) was recorded from 0ton/ha and 25ton/ha compost application rates, respectively (Table 2). the reason for attaining the highest average fresh weight at maximum compost application rate is due to the increased fertility level of the soil, in which the soil can provide the required type and amount of plant nutrient. beside to this an increased level of compost application rate also improves the structure of the soil for easier root penetration and enlargement.

3.2.4. Dry weight

The Analysis of variance for dry weight revealed that there was significant ($p < 0.05$) difference among treatments (Appendix Table 5).

Statistically, the highest dry weight (7.14g/plant) was obtained from the maximum compost application rate (75ton/ha) as compared to the other treatments (Table 2). However, all the rest compost application rates (0ton/ha, 25ton/ha and 50ton/ha) were not significantly different for dry weight. The increased dry weight at maximum compost application rate might be due to the increased ability of the plant to obtain nutrients at

required amount which results in an increase in dry matter of the carrot root.

3.2.5. Shoulder diameter

The analysis of variance for shoulder diameter showed that a highly significance difference ($p < 0.01$) was observed among treatments (Appendix Table 6).

Statistically, the highest shoulder diameter (1.7cm) was recorded at maximum compost application level (75ton/ha) which is highly significantly different from the other treatments. however, all the other treatments (0ton/ha, 25ton/ha and 50ton/ha) are not statistically significantly different (Table 2). The reason for the increase in shoulder diameter of carrot plant at maximum compost application rate might be due to the increased ability of the plant to absorb and utilize the required nutrient from the soil. in addition to this presence of compost at high level would increase the soil physical property and humus level which leads to an increase in root diameter. this result is in line with the result of Dawuda *et al.*, (2011).

Table 2. Treatment means for yield components at Wolkite University, 2017 cropping season.

Treatment (ton/ha)	Root length (cm)	Fresh weight (g/plant)	Dry weight (g/plant)	Shoulder diameter (cm)
	Mean	Mean	Mean	Mean
0	17.41a	6.00c	0.92b	0.68c
25	18.66a	9.86bc	0.85b	0.88bc
50	19.00a	15.20b	1.38b	1.26b
75	19.66 ^a	23.48 ^a	7.14a	1.70 ^a
LSD (at 5%)	3.22	6.75	3.95	0.28
CV (%)	8.63	24.78	26.77	12.49

Note that means with same letter are not statistically significant different, LSD= least significant difference, CV=coefficient of variation

4. Conclusion

The continuous use of inorganic fertilizers for crop production will negatively affect the sustainability of the environment as well as the human health. The research pertaining to the use of organics and bio fertilizers in vegetable crops particularly in carrot is very much limited. So far, no research had been conducted on carrot on different compost application rates at the study area (Wolkite University). Therefore, the goal of the present experiment was to evaluate the growth and yield response of carrot to different rates of compost applications and to determine the optimum application rate for increased growth performance and yield components of carrot.

The experiment was conducted at Horticulture department demonstration site, College of Agriculture and Natural Resources, Wolkite University during 2017 cropping season under supplemental irrigation condition. Complete Randomized Block Design (CRBD) was used with three replication and the treatment consisted of four levels compost rates (0, 25, 50 and 75 tons ha⁻¹). Carrot variety known as "nantes" was used as experimental material. Each treatment was replicated three times and the treatments were randomly assigned to the experimental plots. before during data collection, four plants were randomly selected from each plot and they were tagged . Data were collected, recorded and analyzed on growth and yield components of carrot.

All recorded data were subjected to ANOVA in Randomized complete block Design and the analysis was performed by using Gomez and Gomez text book. The analysis of variance indicated that most of the growth and yield component parameters like plant height, leaf number, fresh weight and shoulder diameter showed highly significant ($P < 0.01$) difference among treatments, whereas dry weight was significantly ($p < 0.05$) different among treatments. However, no significant difference was observed among treatments on the parameter Root Length. The finding of this study indicates that Statistically the highest plant height (29.16cm and 23.91cm) and fresh weight (23.48g and 15.20g) was recorded from compost application rates of 70ton/ha and 50 ton/ha, respectively. Similarly, the highest leaf number (15.16), dry weight (7.14g) and shoulder diameter (1.70cm) per plant was recorded from the maximum compost application rate (75ton/ha). However, no statistical difference was observed among treatments on parameter root length. Thus, from this result we can conclude that compost application at the rate of 75ton/ha can give the maximum record for growth parameters and yield components of carrot. Further to this we recommend the experiment to be conducted across location and year by incorporating additional compost level one or two up together with inorganic fertilizers.

Acknowledgement

We would like to thank Wolkite University for giving the opportunity to use research field, allocating the required labor, materials for field work and vehicle for the research field supervision.

Conflict of Interest

There is no conflict of interest between the authors or anybody else

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6. Appendixes

Appendix Table 1. Analysis of Variance for Leaf Number

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	8.0096	4.0048			
Treatment	3	130.03	37.04	20.396**	4.76	9.78
Error	6	10.898	1.816			
Total	11	148.9376				

Appendix Table 2. Analysis of Variance for Plant Height

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	1.328	0.664			
Treatment	3	246.05	73.27	17.66**	4.76	9.78
Error	6	24.912	4.15			
Total	11	272.29				

Appendix Table 3. Analysis of Variance for Root Length

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	11.845	5.922			
Treatment	3	35.517	2.67	1.02 ^{ns}	4.76	9.78
Error	6	15.652	2.6			
Total	11	63.014				

Appendix Table 4. Analysis of Variance for Fresh Weight

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	17.262	8.631			
Treatment	3	602.137	172.094	15.055**	4.76	9.78
Error	6	68.591	11.431			
Total	11	687.99				

Appendix Table 5. Analysis of Variance for Dry Weight

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	10.804	5.402			
Treatment	3	118.28	28.01	7.166*	4.76	9.78
Error	6	23.452	3.9086			
Total	11	152.536				

Appendix Table 6. Analysis of Variance for Shoulder Diameter

Source of variation	DF	SS	MS	F cal	F tab	
					5%	1%
Rep	2	0.0236	0.0118			
Treatment	3	1.9714	0.609	30.757**	4.76	9.78
Error	6	0.1188	0.0198			
Total	11	2.1138				