*International Journal of Plant & Soil Science*

***Volume 36, Issue 1, Page 148-154, 2024; Article no.IJPSS.111466***
***ISSN: 2320-7035***

# Growth and Yield Response of Carrot (*Daucus carota L.*) to different Soil Amendments

**Abraham Mahari [a*], Emmanuel Solon Jr. [b], and Isaac Sulonteh [b]**

[a] *Department of Natural Resource Management, Cuttington University, Liberia.*
[b] *Department of Plant and Soil Science, Cuttington University, Liberia.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2024/v36i14343

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/111466

***Original Research Article***

***Received: 03/11/2023***
***Accepted: 07/01/2024***
***Published: 17/01/2024***

## ABSTRACT

Carrot (*Daucus carota L.*) is an important vegetable that is ranked tenth among the succulent vegetables in the world. It is easy to cultivate and requires a moderate amount of nutrients in comparison to other vegetables. However, carrot production in Liberia is almost negligible, as farmers are not aware of its requirements, its cultivation, and the unsuitable environmental conditions. The objective of this study was to assess the growth and yield performance of carrot under different soil amendments. The experiment was done at the Cuttington University research and demonstration site in a randomized complete block design (RCBD) with three replications. The treatments were: 10 t $ha^{-1}$, 15 t $ha^{-1}$, and 20 t $ha^{-1}$ compost; 300 t $ha^{-1}$ NPK (15:15:15); and control (0 t $ha^{-1}$). The distance between plots and between blocks was 0.5 m and 1 m, respectively. Results indicated that The highest recorded plant root length (11.10 cm) occurred in the 20 t $ha^{-1}$ compost application, while the lowest (6.84 cm) was observed in the control treatment. The highest root diameter (22.89 mm) was recorded in the treatment with 20 t $ha^{-1}$ while the lowest (17.59 mm) was

**Corresponding author: E-mail: abmahari@gmail.com; amahari@cu.edu.lr;*

recorded in the control treatment. Results showed that the maximum root weight (31.73 g) occurred in the 20 t $ha^{-1}$ compost treatment, while the minimum (12.33 g) was observed in the control. These variations are likely attributed to nutrient levels, which play a vital role in promoting root length, diameter, and overall yield in the plant. That means the lowest values in all the parameters might be due to the low rate of compost applied to the soil. In conclusion, the highest overall growth and yield performance among carrot plants were observed in the 20 t $ha^{-1}$ compost treatment, followed by 15 t $ha^{-1}$, 300 t $ha^{-1}$ NPK (15:15:15), 10 t $ha^{-1}$, and the control. It is therefore recommended that farmers apply 20 t $ha^{-1}$ of compost for maximum growth and yield performance in carrot production.

*Keywords: Carrot; compost; soil amendment; yield response; Liberia.*

## 1. INTRODUCTION

Carrot (*Daucus carota L.*) is a highly valued vegetable that ranks tenth among the succulent vegetables and is renowned for its vibrant orange color and remarkable nutritional value [1]. This important root vegetable, which is a member of the Umbelliferae family [2], is eaten both raw and cooked. Carrot is prized for having a high beta-carotene content [3,1] which is a precursor to vitamin A and is known to protect against infections and some cancers [4,5,6] and improve vision [7]. It is also an essential part of the diet since it is high in riboflavin B2, vitamin C, and thiamin B1 [8].

Carrot responds favorably to a variety of inorganic and organic fertilizers [9]. However, excessive use of inorganic fertilizers leads to adverse consequences such as soil acidification, increased greenhouse gas emissions, and increased eutrophication of water bodies [10,11,12]. These negative consequences deteriorate the nutritional value of crops in addition to compromising crop productivity. On the other hand, excessive organic matter in the soil can induce forking in the carrot, which reduces its marketability and profitability [13,14].

A sustainable option to improve carrot quality and yield while addressing the environmental issues caused by inorganic fertilizers is soil amendment with compost [15,16]. Poor soil and inadequate crop management techniques, particularly in sub-Saharan Africa, have been identified as important contributors to low crop yields and decreased nutritional value [17]. These difficulties are exacerbated by the limited availability of resources and production knowledge, such as high-quality seeds and fertilizers [18].

Despite being considered a medium feeder, carrots still demand fertile soil for optimal growth [19]. Improper organic fertilizers can cause carrot roots to become excessively coarse, gritty, and twisted [20]. Other variables, such as temperature, poor soil structure, high nitrogen fertilizer rates, high clay content, and varying soil moisture levels, can contribute to these root deformities [21]. Furthermore, in soils in wet locations with acidity and leaching properties, high fertilizer may be required to improve the soil structure [22,23]. Timing of organic fertilizer application, along with soil temperature and pH, also plays a crucial role in nutrient availability and uptake [24].

In Liberia, where carrot production is currently almost nonexistent due to soil management challenges, this study was aimed at assessing the yield response of carrot (*Daucus carota L.*) to different soil amendments and evaluating the impact of varying amendment rates on its growth. Enhancing carrot production through sustainable soil management practices can contribute significantly to improving the livelihoods of local farmers and increasing the availability of this nutritious vegetable in the market.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

The study was conducted at the Cuttington University research and demonstration site in Suakoko, Bong County, Liberia. The experimental site lies at an altitude of 270 m above sea level and is located at 7.0451° latitude and -9.5508° longitude. Climatic variables such as temperature and rainfall pattern are largely tropical, with an annual average temperature of 25 °C and an annual average rainfall of 2013 mm distributed from May to October. The main soil types in the district include latosols, lithosols, regosols, and alluvial or swamp soils [25,26].

### 2.2 Experimental Design and Treatments Application

The experimental area was slashed, ploughed, and harrowed to a fine tilth. The debris was raked off the field, and the area was demarcated into three blocks. A block had 5 plots, each measuring 1 m long, 1 m wide, and 0.25 m high. The experiment was done in a randomized complete block design (RCBD) with three replications. Following the methods by Srn [23], the treatments (soil amendments) considered in the study were: 10 t $ha^{-1}$, 15 t $ha^{-1}$, and 20 t $ha^{-1}$ compost; 0.33 t $ha^{-1}$ NPK (15:15:15); and control. The distance between plots and between blocks was 0.5 m and 1 m, respectively. The various rates of compost were incorporated into the soil during the preparation of the beds, while the NPK fertilizer granules were applied thirty days after the germination of the carrot seeds by side dressing.

According to Bolkunov [27], the seeds were drilled to a depth of 1-2 cm. Before watering, gardens were mulched by covering them with palm fronds. After seeding, the palm fronds were cut off fourteen days later, and the seedlings were spaced out to a maximum of five centimeters between each plant. To maintain the soil's moisture content during the growth season, daily irrigation was conducted. Twice a week, the areas between the rows of carrot plants were turned over with a hand fork to get rid of weeds and soften the soil for better aeration and infiltration. In order to keep the root shoulders from turning green, they were covered with soil.

### 2.3 Sample size determination

From a total population of 2,565 plants, the required sample size was determined following Ismail [28].

$$N/1+N(e^2)$$

Where: N is the total population; e is the margin sampling error.

However, during the germination period of the seeds, torrential rainfall came and caused damage to the newly emerged seedlings. Therefore, data was collected from the available plants: 9 samples from 10 t $ha^{-1}$, NPK, and control; 27 samples from 20 t $ha^{-1}$; and 18 samples from 15 t $ha^{-1}$, totaling 72 sampling plants, were collected.

### 2.4 Data Collection Procedures

Data was collected on root length, root weight, and root diameter from 72 plants, which were randomly selected. Root length was measured from one end to the tip of the other end. Veneer calipers were used to measure the root diameter at a distance of around 1 cm from the root shoulder following the procedures by Md Saleh [29]. We used a digital balance to find the root weight.

### 2.5 Statistical Analysis

Data on plant growth performance and yield of carrots was summarized using descriptive statistics such as mean and standard errors. An analysis of variance (ANOVA) was performed to see if there were any significant differences among the selected treatments. Pearson correlation analysis was also done to see if there was any relationship between the parameters. Mean comparisons were made using the Tukey Honest Significant Difference (TSD) at 0.05 significant levels. The IBM SPSS 25 package was used to perform all the statistical analyses.

## 3. RESULTS AND DISCUSSION

### 3.1 Root Length

The length of the root is a crucial parameter affecting the yield of root vegetables. In our study, we observed that the measured root length of carrot plants was significantly influenced by the application of different rates of compost and NPK fertilizer (Table 1). There was a noticeable increase in plant root length as the amount of compost increased. The longest plant root length recorded was 11.10 cm in the 20 t $ha^{-1}$ compost application, while the lowest root length, 6.84 cm, was measured in the control treatment. This difference in root length can likely be attributed to the low nutrient levels in the control treatment, which may have constrained root growth and development.

Our findings align with the research of Yasoda et al. [18], who reported that carrot root length tends to perform best in soils with a high compost content. Dry soils can cause cracking in carrot roots [30], leading to an increased percentage of rotten roots and a subsequent decrease in plant yield [31]. In contrast, favorable soil conditions with a high compost level promote the development of longer roots and enhance overall yield.

Similarly, our results are consistent with the findings of Rahman et al. [24], who noted a significant improvement in carrot growth and yield with the application of compost compared to

**Table 1. Root length, root diameter, and root weight comparisons among the selected treatments**

| Treatment | Root length (cm) | Root diameter (mm) | Root weight (g) |
|---|---|---|---|
| 10 t $ha^{-1}$ compost | $(7.67 \pm 1.08)^{bc}$ | $(18.45 \pm 1.63)^{ab}$ | $(16.90 \pm 2.37)^{b}$ |
| 15 t $ha^{-1}$ compost | $(10.52 \pm 0.55)^{ab}$ | $(19.96 \pm 1.00)^{ab}$ | $(22.93 \pm 2.92)^{ab}$ |
| 20 t $ha^{-1}$ compost | $(11.10 \pm 0.52)^{a}$ | $(22.89 \pm 0.72)^{a}$ | $(31.73 \pm 2.46)^{a}$ |
| control | $(6.84 \pm 0.73)^{c}$ | $(17.59 \pm 1.30)^{b}$ | $(12.33 \pm 1.38)^{b}$ |
| 0.33 t $ha^{-1}$ NPK (15:15:15) | $(8.22 \pm 1.20)^{abc}$ | $(22.82 \pm 1.63)^{ab}$ | $(20.19 \pm 4.47)^{ab}$ |

**Means followed by the same letter are not significantly different at P ≤ 0.05 as determined by Tukey Honest Significant Difference (HSD) test. Values are expressed as mean ± standard error.*

the control. Specifically, compost application at rates between 15 to 20 t $ha^{-1}$ led to a substantial enhancement in carrot plant performance.

## 3.2 Root Diameter

The root diameter of carrot plants was significantly influenced by different levels of compost and NPK applications in our study. The mean values of root diameter exhibited a consistent increase as the rate of compost application increased. The highest root diameter, measuring 22.89 mm, was observed in the treatment with 20 t $ha^{-1}$ compost, while the lowest mean root diameter, 17.59 mm, was recorded in the control treatment with no compost (0 t $ha^{-1}$) (Table 1). These findings are consistent with the results reported by Fikadu and Refisa (2019), who noted the significant impact of compost application on carrot root diameter.

Our study clearly demonstrates that as the rate of compost application increases, the root diameter of carrot plants also increases. These results are consistent with the observations made by Asante et al. (2019), who reported significant variations in carrot root diameter with the application of both chemical fertilizers and organic manures.

## 3.3 Root weight

Root weight stands as a critical parameter influencing the yield of root vegetables. In our study, significant differences ($p < 0.001$) were observed among the five different treatments. Notably, the average root weight of carrot plants exhibited a consistent increase with higher levels of compost, resulting in substantially greater root weight in the NPK treatment compared to the 10 t $ha^{-1}$ and control treatments. Specifically, the highest root weight, measuring 31.73 g, was recorded at the 20 t $ha^{-1}$ compost rate, while the lowest, 12.33 g, was observed in the control treatment. The enhanced response in root fresh weight at the 20 t $ha^{-1}$ compost rate is likely attributable to the improved soil fertility status resulting from the increasing levels of compost. This discrepancy in root weight may be attributed to the relatively low compost application rate in the control treatment, potentially limiting nutrient availability in the soil. This finding aligns with the research by Mbatha et al. [8], which suggests a direct correlation between carrot yield and the quantity of compost applied to the soil.

Our results corroborate the findings of Yasoda et al. [18], who highlighted the nutrient-rich nature of compost. They reported that consistent compost applications not only supply essential plant nutrients but also enhance soil fertility. Similarly, Rahman et al. [24] demonstrated that compost leads to increased nitrogen uptake and improved carrot yield. However, it's important to note that nutrient availability in the soil can vary significantly based on the nutrient source.

Furthermore, Kiran et al. [32] observed a significant boost in plant growth and carrot yield with higher doses of compost compared to lower doses, supporting our findings. A similar investigation conducted by Achakzai and Panizai [21] focused on the effect of compost on carrot yield reported that the highest root fresh weight, 160.70 g, was achieved with a 15 t $ha^{-1}$ compost application. Likewise, Snr et al. [23] reported that the maximum root fresh weight, 146.50 g, was obtained with a 25t $ha^{-1}$ compost application, while the lowest (123.96 g) was observed in the control treatment. Dawuda et al. [33] also found that the application of bio-slurry manure at 7.8 t $ha^{-1}$ led to a 23.5% increase in carrot yield compared to the control. The current study aligns with the findings of Kiran et al. [32], who emphasized the effectiveness of compost in enhancing soil fertility, particularly for growing vegetable crops. Similarly, Adelaide [13] highlighted compost as a valuable fertilizing material capable of maintaining soil fertility and improving crop production.

**Table 2. The correlation matrix of the root length, root weight, and root diameter**

| | Root length (cm) | Root weight (g) | Root diameter (mm) |
|---|---|---|---|
| Root length (cm) | | 0.698 | 0.492 |
| Root weight (g) | 0.698 | | 0.736 |
| Root diameter (mm) | 0.492 | 0.736 | |

Correlation analysis revealed strong positive correlations among root length, root diameter, and root weight (Table 2). The Pearson correlation coefficient indicated a robust relationship between root length and root weight ($r$ = 0.698), as well as between root diameter and root weight ($r$ = 0.736). Although the correlation between root length and root diameter was slightly lower ($r$ = 0.492), it still provides valuable insight into the relationship between these two variables [34,35].

## 4. CONCLUSION

The present study has yielded vital insights on the notable effects of NPK fertilizer and compost on root weight, root diameter, and root length in carrot plants. According to the study, the amount of compost that is added to the soil has a significant impact on the length of carrot roots. The application of 20 t $ha^{-1}$ of compost resulted in the longest roots among carrot plants, suggesting a favorable correlation between compost levels and root length.

The study also demonstrated the positive link that exists between root length, root diameter, and root weight, highlighting the interdependent nature of these factors in affecting the growth and yield of carrot plants. The relevance of these parameters in influencing overall root vegetable output is highlighted by the substantial correlations found between root diameter and weight and between root length and weight. This study highlights how crucial it is to maintain soil properly, using compost, in order to optimize root characteristics and eventually increase the yield of root crops like carrots.

In conclusion, this study's findings advance our knowledge of the significant effects that NPK fertilizer treatments and compost can have on the length, width, and weight of carrot plants' roots. Farmers and other agricultural professionals who want to increase the yield of root vegetables by using efficient soil nutrient management techniques may find these ideas to be helpful. This research highlights the possibility for greater agricultural production and food security in areas where root vegetables are important for dietary diversity and nutrition by highlighting the significance of soil fertility and nutrient levels.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Nagraj GS, Jaiswal S, Harper N, Jaiswal AK. Carrot. Nutritional Composition and Antioxidant Properties of Fruits and Vegetables. 2020;323-337.
2. Ismail J, Shebaby W, Daher J, Boulos JC, Taleb R, Daher CF, Mroueh M. The wild carrot (Daucus carota): A Phytochemical and Pharmacological Review. Plants. 2023;13(1):93.
3. Ebadollahi-Natanzi A, Arab-Rahmatipour G. A study on chlorophyll, total carotenoid and beta-carotene contents in carrot and the effect of climate on them. Journal of Medicinal Plants. 2020;19(75):254-265.
4. Key TJ. Fruit and vegetables and cancer risk. British Journal of Cancer. 2011;104 (1):6-11.
5. Zaini R, Brandt K, R Clench, M, L Le Maitre C. Effects of bioactive compounds from carrots (Daucus carota L.), polyacetylenes, beta-carotene and lutein on human lymphoid leukaemia cells. Anti-Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Anti-Cancer Agents). 2012;12(6):640-652.
6. Xu H, Jiang H, Yang W, Song F, Yan S, Wang C, Fu W, Li H, Lyu C, Lu Z. Is carrot consumption associated with a decreased risk of lung cancer? A meta-analysis of observational studies. British Journal of Nutrition. 2019;122(5):488-498.
7. Krinsky NI, Johnson EJ. Carotenoid actions and their relation to health and disease. Molecular aspects of medicine. 2005;26(6):459-516.
8. Mbatha AN, Ceronio GM, Coetzer GM. Response of carrot (*Daucus carota L.*) yield and quality to organic fertiliser. South

African Journal of Plant and Soil. 2014; 31(1):1–6.

9. Kushwah G, Sharma RK, Kushwah SS, Mishra SN. Effect of organic manures, inorganic fertilizers and varieties on growth, yield and quality of tropical carrot. Indian Journal of Horticulture. 2019; 76(3);451-456.
10. Kumar R, Kumar R, Prakash O. Chapter-5 the impact of chemical fertilizers on our environment and ecosystem. Chief Ed. 2019;35:69.
11. Rashmi I, Roy T, Kartika K S, Pal R., Coumar V, Kala S, & Shinoji KC. Organic and inorganic fertilizer contaminants in agriculture: Impact on soil and water resources. Contaminants in Agriculture: Sources, Impacts and Management. 2020; 3-41.
12. Tyagi J, Ahmad S, Malik M. Nitrogenous fertilizers: Impact on environment sustainability, mitigation strategies, and challenges. International Journal of Environmental Science and Technology. 2022;19(11):11649-11672.
13. Adelaide M. Influence of temperature on yield and quality of carrots *(Daucus carota var. sativa)*. 2011;1–84.
14. Akologo LA, Dapaah HK, Yirzagla J. Recommended carrot production and handling practices. Emerging Issues in Agricultural Sciences. 2023;132.
15. Habteweld AW, Brainard D, Kravchenko A, Grewal PS, Melakeberhan H. Effects of plant and animal waste-based compost amendments on the soil food web, soil properties, and yield and quality of fresh market and processing carrot cultivars. Nematology. 2018;20(2):147-168.
16. Bender I, Edesi L, Hiiesalu I, Ingver A, Kaart T, Kaldmäe H, Talve T, Luik A. Organic carrot (Daucus carota L.) production has an advantage over conventional in quantity as well as in quality. Agronomy. 2020;10(9):1420.
17. Biramo G. The role of integrated nutrient management system for improving crop yield and enhancing soil fertility under Small holder farmers in Sub-Saharan Africa: A review article. Mod. Concepts Dev. Agron. 2018;2:1-9.
18. Yasoda PGC, Pradheeban, L, Nishantha K, Sivachandiran S. Effect of Different Shade Levels on Growth and Yield Performances of Cauliflower. International Journal of Environment, Agriculture and Biotechnology. 2018;3(3):948–955.
19. Thapa A, Garhwal BTT, Srivastava UA, Shrestha AK, Giri HN, Effect of Different Levels of Potassium and Boron on Growth, Yield and Quality of Carrot (Daucus carota cv. New Kuroda) in Nawalparasi, Nepal. International Journal of Innovative Science and Research Technology. 2023;8(2); 1640-1647.
20. Dickinson B. Gardening to Eat: Connecting People and Plants. Gardening to Eat. 2021;1-152.
21. Achakzai AKK, Panizai MK. Effect of Row Spacing on Growth , Yield and Yield Components of Mashbean. Journal of Horticulture. 2007;23(1):149–155.
22. Osman KT, Osman KT. Acid soils and acid sulfate soils. Management of Soil; 2018.
23. Snr PAP, Addo JS, Logah V, Kyere CG. Effect of Different Soil Amendments and Variety on the Growth and Yield of Carrot (*Daucus carota L.*). International Journal of Plant & Soil Science. 2020;32(10):16–25.
24. Rahman M, Islam M, Mamun M, Rahman M, Ashraf M. Yield and Quality Performance of Carrot under Different Organic and Inorganic Nutrient Sources with Mulching Options. Asian Journal of Agricultural and Horticultural Research. 2018;1(4):1–8.
25. Samuel KJ, Omobolanle NM, Monday S Ebenezer O. Determinants of Households' Participation in Environmental Sanitation in Liberia: A Case Study of Duport Road Community, Monrovia. International Journal of Health Sciences. 2022;3:8145-8155.
26. Koon AB, Anornu GK, Dekongmen BW, Sunkari ED, Agyare A, Gyamfi C. Evaluation of groundwater vulnerability using GIS-based DRASTIC model in Greater Monrovia, Montserrado County, Liberia. Urban Climate. 2023;48:101427.
27. Bolkunov AI, Postnova MV, Sroslova GA. Features of the cultivation technology of carrot hybrids in dry steppes of the Lower Volga region on drip irrigation. In IOP Conference Series: Earth and Environmental Science, IOP Publishing. 2019;341(1):012001.
28. Ismail IA, Pernadi NL, Febriyanti A. How to grab and determine the size of the sample for research. International Journal of Academic and Applied Research (IJAAR). 2022;6(9):88-92.
29. Md Saleh R, Kulig B, Arefi A, Hensel O, Sturm B. Prediction of total carotenoids,

color, and moisture content of carrot slices during hot air drying using non-invasive hyperspectral imaging technique. Journal of Food Processing and Preservation. 2022;46(9):e16460.

30. Eshkurbanovich AI, Asadullaevich RE, Jumaevich CA, Rustamovna XM. Evaluation of varieties and hybrids of table carrot (daucus carota l.) Grown in conditions of desert soil-climate zone of surkhandarya region. Open Access Repository. 2022;8(12):295-299.
31. Villeneuve F, Geoffriau E. Carrot physiological disorders and crop adaptation to stress. In Carrots and related Apiaceae crops (pp.). Wallingford UK: CABI. 2020:156-170
32. Kiran M, Jilani MS, Waseem K, Marwat SK. Response of Carrot (*Daucus carota L.*) Growth and Yields to Organic Manure and Inorganic Fertilizers. American-Eurasian J. Agric. & Environ. Sci. 2016;16(6):1211–1218.
33. Dawuda M, Boateng P, Hemeng O, Nyarko G. Growth and yield response of carrot (Daucus carota l.) to different rates of soil amendments and spacing. Journal of Science and Technology (Ghana). 2011;31 (2);11–20.
34. Fikadu L, Refisa J. The Effect of Different Rates of Cow Dung Application on Growth and Yield of Carrot (*Daucus carrota L.*). International Journal of Agriculture & Agribusiness. 2019;6(1):21–27.
35. Asante K, Manu-Aduening J, Essilfie ME. Nutritional Quality Response of Carrot (Daucus carota) to Different Rates of Inorganic Fertilizer and Biochar. Asian Journal of Soil Science and Plant Nutrition. 2019;5(2):1–14.

---

*© 2024 Mahari et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/111466*