

Research Article

# Growth and Yield Response of Carrot (*Daucus carota* L.) to Fertilizer Rate in Wolaita Zone, Southern Ethiopia

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## Abstract

Carrot (*Daucus carota* L.) is a significant root vegetable cultivated and consumed in Ethiopia. However, there has been limited research on the optimal fertilizer rates to enhance carrot growth and yield in the Wolaita zone. A field experiment was carried out to assess the impact of four different rates of NPS fertilizer (0 kg ha<sup>-1</sup>, 60 kg ha<sup>-1</sup>, 120 kg ha<sup>-1</sup>, and 180 kg ha<sup>-1</sup>) and four rates of urea fertilizer (0 kg ha<sup>-1</sup>, 45 kg ha<sup>-1</sup>, 90 kg ha<sup>-1</sup>, and 135 kg ha<sup>-1</sup>) on carrot growth and yield. Most growth parameters, except root length per plant, leaf length per plant at both sites, and core diameter per plant at Delbo, were significantly affected by the fertilizer rates. The highest plant height (32.6 cm) with 120 kg/ha NPS and 90 kg/ha urea, leaf number per plant (12.1) and shoot weight per plant (7.4 g) at 180 kg/ha NPS and 135 kg/ha urea, shoot dry weight per plant (1.5 g) at 0 kg/ha NPS and 135 kg/ha urea, root diameter (2.4 cm) at 60 kg/ha NPS and 90 kg/ha urea, root fresh weight per plant (31.3 g), root yield, and marketable yield (31,333 kg/ha) at 180 kg/ha NPS and 90 kg/ha urea, and root dry weight per plant (2.9 g) at 120 kg/ha NPS and 45 kg/ha urea were recorded at Delbo. At Soddo site, the highest plant height (43.3 cm), root weight per plant (29.0 g), root yield (32,333 kg/ha) at 120 kg/ha NPS and 0 kg/ha urea, leaf number (9.5) at 0 kg/ha NPS and 135 kg/ha urea, shoot weight per plant (11.1 g) at 60 kg/ha NPS and 0 kg/ha urea, shoot dry weight per plant (2.4 g) at 60 kg/ha NPS and 135 kg/ha Urea, marketable yield (27,800 kg/ha) at 120 kg/ha NPS and 135 kg/ha Urea, root dry weight per plant (3.3 g) and shelf life (24.0 days) at 0 kg/ha NPS and 0 kg/ha Urea was obtained, respectively. Applying a fertilizer rate of 180 kg/ha NPS and 90 kg/ha at Delbo, along with a rate of 120 kg/ha NPS and 135 kg/ha at Soddo, demonstrated the potential to enhance carrot productivity in the experimental region and in areas with comparable environmental conditions. It is advisable to conduct this study again in various seasons to provide more accurate recommendations.

## Keywords

Carrot, Carrot Growth, NPS, Urea, Carrot Yield

## 1. Introduction

Carrot (*Daucus carota* L.) is a biennial herbaceous plant that can thrive in various environments. During its first growing season, it focuses on developing leaves and roots, while in the second season, it utilizes the roots as a storage organ to produce new leaves and flowers [19, 18]. In Ethio-

pia, promoting carrot cultivation and increasing domestic consumption is seen as a strategy to enhance nutritional standards and mitigate the prevalence of night blindness in mothers and children, which is often linked to vitamin A deficiency [3]. Additionally, carrots are rich in a variety of

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antioxidants, vitamins, carbohydrates, crude fiber, and essential minerals such as calcium, phosphorus, iron, and magnesium [27].

In Ethiopia, carrot productivity was recorded at approximately 3.87 tons per hectare in the 2014/15 growing season and 4.38 tons per hectare in 2015/16 [4]. However, these yields remain significantly lower than the expected range of 8-12 tons per hectare for tropical regions and the global average of 21 tons per hectare [12]. The lower productivity of carrots in the country can be attributed to inadequate agricultural practices, including improper sowing times, a lack of high-yielding varieties, insufficient spacing, and ineffective management of weeds, pests, and diseases, as well as inadequate irrigation [28]. Factors such as fertilization levels and soil tillage may also interact in various ways, depending on the specific cultivar [2].

To achieve high yields, it is essential to have fertile soil that supports the production and movement of carbohydrates from the leaves to the roots. Key nutrients such as nitrogen, phosphorus, potassium, and sulfur are critical limiting factors that influence the growth, development, and yield of crops [22]. Typically, carrot farmers rely on inorganic fertilizers as their primary nutrient source to enhance growth and yield [5].

While a recommendation of 100 kg/ha of DAP and 100 kg/ha of urea fertilizer has been made for Eastern Ethiopia [29], there has yet to be a systematic investigation into the optimal fertilizer rates for maximizing carrot root yield in the Wolaita zone. Consequently, this study aims to identify the suitable rates of NPS and urea for improving carrot production and productivity in the region.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The experiments were carried out under rain-fed conditions on a farm located in the Damot Galee and Soddo Zuria districts of the Wolaita zone in Ethiopia during the 2019 cropping year. The site is situated at a latitude of  $6^{\circ} 49' N$  and a longitude of  $37^{\circ} 45' E$ , with an elevation of 1,886 meters above sea level. This region experiences a bimodal rainfall pattern, with the shorter rainy season occurring from March to April and the primary rainy season from June to September, which is when carrots are predominantly cultivated. Historical data from the past twelve years (2003-2015) indicates that the average annual rainfall is approximately 1,580 mm, while the average maximum and minimum temperatures are  $23.7^{\circ} C$  and  $17.7^{\circ} C$ , respectively. In August, the relative humidity in the area reaches 75.2%, whereas it can drop to as low as 56.0% in February [21]. The prevalent soil type in the Wolaita region is a well-drained sandy loam characterized by low organic matter content [10].

### 2.2. Treatments and Experimental Designs

The experiment was carried out using a factorial combination of four urea application rates (0, 45, 90, and  $135 \text{ kg ha}^{-1}$ ) and four NPS application rates (0, 60, 120, and  $180 \text{ kg ha}^{-1}$ ) as treatments. It was organized in a randomized complete block design (RCBD) with three replications. Each plot measured  $1.5 \text{ m}^2$  ( $1.25 \text{ m} \times 1.2 \text{ m}$ ). The spacing between rows was 25 cm, while the spacing between plants was 10 cm. A 1 m wide space separated the blocks, and there was a 0.5 m space between each plot. All plots received equal watering and other necessary cultural practices.

### 2.3. Field Management and Cultural Practice

The experimental field was meticulously ploughed using locally sourced materials to a depth of 30 cm to achieve a fine tilth. It was then leveled and segmented into plots according to the experimental design. Seeds were sown at a depth of 1.5 cm in rows. A half dose of nitrogen and a full dose of NPS were applied as a basal treatment on the sowing date and thoroughly mixed with the soil. The remaining half dose of nitrogen was applied as a top dressing following thinning, in accordance with the treatment protocols. Two rounds of thinning were conducted to ensure optimal plant population. The first thinning occurred 20 days after sowing, while the second took place 10 days after the first thinning. Additionally, earthing up of the plants was performed twice, at 30 and 60 days post-sowing, to cover any exposed roots.

### 2.4. Data Collected

Root yield was obtained from the entire net plot, while for the other parameters; ten plants from the central rows were randomly selected and tagged for data collection as follows:

Plant height (cm): was measured as the distance from the ground level to the tip of the plant at maturity.

Number leaf per plant: the total number of leaves per plant was counted at harvest, and the average number of leaves per plant was calculated.

Leaf length (cm): was measured from the apex to the base of the leaf, and the average was determined.

Plant shoot fresh weight ( $\text{g plant}^{-1}$ ): the above-ground portions of the plants were harvested to record their fresh weight, with the average expressed in grams.

Shoot dry weight ( $\text{gm plant}^{-1}$ ): following the fresh weight measurement, the above-ground parts were dried in an oven at  $60^{\circ} C$  until a constant weight was achieved, allowing for the recording of shoot dry weight with the average also expressed in grams.

Root weight per plant (g): was recorded by harvesting selected plants from each plot, and the average was expressed in grams.

Root length (cm): was measured from the apex to the base of the root, and the average was calculated.

Root diameter (cm): was measured from one edge through

the center to the opposite edge at the middle of the root.

Root dry weight (g plant<sup>-1</sup>): the roots were subjected to drying in an oven at 60 °C until a stable weight was reached, after which their dry weight was recorded. The average dry weight of the roots was reported in grams per plant.

Root yield (kg per hectare): roots were collected from the designated plot, weighed, and the yield was expressed in kilograms per hectare.

Marketable root yield (kg per hectare): the ratio of marketable to unmarketable roots was assessed by evaluating the roots for size and quality. Oversized, undersized, branched, cracked, and damaged carrots were classified as unmarketable based on farmers' perceptions, while the remaining roots were deemed marketable.

Core diameter (cm): the harvested roots were sliced, and the thickness of the slices taken from the middle section of the tap root was measured and recorded in centimeters.

Shoot water content and root water content (%): The water content of the carrots was calculated using the formula provided by Keshavarzpour (2011):  $\text{Water content (\%)} = 100 \times (M_1 - M_2) / M_1$ , where  $M_1$  represents the weight before drying and  $M_2$  denotes the weight after drying.

Harvested root shelf life (days): Shelf life was defined as the duration (in days) from the harvest of the roots until the end of their edible life at room temperature. The end of shelf life was identified as the point at which 50% of the stored roots were no longer suitable for consumption.

Total soluble solids: This measurement was derived using a linear regression model as outlined by Keshavarzpour (2011):  $\text{TSS} = 34.9 - 0.30 \text{ WC}$ , where TSS stands for total soluble solids and WC represents water content.

## 2.5. Data Analysis

The data were examined utilizing the Generalized Linear Model (GLM) procedures available in the Statistical Analysis System (SAS) software [26]. To distinguish significant differences among treatment means, Fisher's Least Significant Difference (LSD) test was applied at  $\alpha = 0.05$ , following the analysis of variance that indicated  $P \leq 0.05$ .

## 3. Results and Discussion

The impact of varying rates of NPS and Urea on plant height, leaf count, shoot weight per plant, shoot dry weight per plant, and shoot water content was found to be signifi-

cant ( $P < 0.05$ ), while leaf length did not show significant differences at both Delbo and Sodoo sites. At the Delbo site, the tallest plants (32.6cm) were observed with the application of 120 kg/ha NPS and 90 kg/ha Urea. The highest leaf count per plant (12.1) and shoot weight per plant (7.4g) were achieved with 180 kg/ha NPS and 135 kg/ha Urea. Additionally, the maximum shoot dry weight per plant (1.5g) was recorded with 0 kg/ha NPS and 135 kg/ha Urea, while the highest shoot water content per plant (93.4%) was noted with 0 kg/ha NPS and 0 kg/ha Urea. In the Soddo site, the greatest plant height (43.3cm) was also recorded with 120 kg/ha NPS and 0 kg/ha Urea. The highest leaf count (9.5) was achieved with 0 kg/ha NPS and 135 kg/ha Urea, while the maximum shoot weight per plant (11.1g) was noted with 60 kg/ha NPS and 0 kg/ha Urea. Furthermore, the highest shoot dry weight per plant (2.4g) was obtained with 60 kg/ha NPS and 135 kg/ha Urea, and the maximum shoot water content per plant (92.22%) was recorded with 120 kg/ha NPS and 45 kg/ha Urea, as detailed in Table 1.

The minimum plant height recorded was 21.9 cm, with a shoot weight per plant of 3.1 g and a shoot dry weight of 0.2 g, observed at 0 kg/ha NPS and 0 kg/ha Urea. The lowest leaf count, which was 8.2, was noted at 180 kg/ha NPS combined with 0 kg/ha Urea. Additionally, the lowest shoot water content per plant, measured at 73.1%, occurred at 0 kg/ha NPS and 135 kg/ha Urea at Delbo. In Soddo, the lowest plant height of 35.4 cm and the lowest shoot dry weight of 0.5 g were also recorded at 0 kg/ha NPS and 45 kg/ha Urea. Furthermore, the lowest leaf number of 7.1 was found at 0 kg/ha NPS and 135 kg/ha Urea, while the lowest shoot weight per plant was 3.4 g and the shoot water content was 82.3%, both at 0 kg/ha NPS and 90 kg/ha Urea (Table 1). Overall, as the rate of fertilization increased, so did vegetative growth, indicating that fertilizers play a crucial role in enhancing this growth. These findings align with previous studies by [16, 13, 14, 23], which reported significant growth variations in carrots due to chemical fertilizer application. Additionally, [15] noted that the use of commercial fertilizers significantly improved carrot growth, attributed to the readily available nutrients they provide. Similar observations were made by [20], who found that plant height increased progressively with higher fertilizer application levels in carrots. [18] also reported that increased nitrogen application led to a greater number of leaves. Moreover, [24] documented statistically significant variations in the fresh weight of leaves per plant at different phosphorus levels.

**Table 1.** Effect of fertilizer rate (kg/ha) on growth parameters of carrot.

Delbo					Soddo				
NPS rate	Urea rate	PH	LNPP	SWPP	SDWPP	PH	LNPP	SWPP	SDWPP
0	0	21.9b	8.7b	3.1e	0.2h	39.5abcdef	8.5abc	7.8bcd	1.3bc

	Delbo					Soddo			
NPS rate	Urea rate	PH	LNPP	SWPP	SDWPP	PH	LNPP	SWPP	SDWPP
60	45	26.9ab	8.5b	3.4de	0.7ef	35.4f	8.1abc	5.8ef	0.5i
	90	29.2ab	8.9b	4.8c	0.5g	36.6cdef	7.3c	4.1g	0.7fghi
	135	25.1ab	9.9b	3.9d	1.5a	37.7bcdef	7.1c	4.9fg	0.9efgh
	0	24.4ab	8.7b	3.7de	0.7e	38.2bcdef	8.8ab	11.1a	1.5b
	45	27.9ab	9.1b	4.7c	1.1cd	36.3def	7.5bc	5.8ef	0.7ghi
	90	31.7a	9.5b	7.2a	1.1cd	36.1ef	7.5bc	6.8de	1.0cdef
	135	31.9a	9.1b	5.1bc	0.5fg	40.7abc	7.7bc	8.1bcd	2.4a
	0	26.8ab	9.5b	4.9c	1.1cd	43.3a	7.5bc	8.9b	1.1cde
120	45	26.8ab	9.3b	5.3bc	1.3b	40.9abc	8.4abc	8.5bc	0.6hi
	90	32.6a	9.9b	5.7b	1.2bc	38.7bcdef	7.6bc	7.8bcd	1.2cd
	135	27.9ab	8.9b	4.9c	0.5g	41.1ab	7.5bc	7.9bcd	1.2cde
	0	29.4ab	8.2b	4.9c	0.6efg	40.5abcd	8.4abc	8.3bc	1.2cde
180	45	28.7ab	9.2b	4.9c	0.7e	40.0abcde	7.3c	7.3cd	1.1cde
	90	29.4ab	9.4b	5.8b	1.1cd	36.3def	8.2abc	7.2cde	1.3bc
	135	27.5ab	12.1a	7.4a	1.0d	39.1abcdef	9.5a	9.1b	0.9defg
LSD (0.05)		9.2	2.2	0.9	0.2	4.4	1.4	1.5	0.3
CV (%)		19.7	14.0	9.4	10.3	6.6	12.0	16.5	23.5

Means followed by the same letter with in the column are not different from each other at P=0.05 level of significance. Where, PH = plant height (cm), SDWPP = shoot dry weight per plant (cm), SWPP = shoot weight per plant and LNPP = leaf number per plant.

The analysis of yield parameters, excluding root length per plant, indicated significant variations ( $P < 0.05$ ) between different fertilizer rates of NPS and Urea. The maximum root diameter of 2.4 cm was observed with the application of 60 kg/ha NPS and 90 kg/ha Urea. Additionally, the highest root fresh weight per plant was 31.3 g, and the root yield reached 31,333 kg/ha, both recorded at 180 kg/ha NPS combined with 90 kg/ha Urea. The peak root dry weight per plant, measuring 2.9 g, was noted at 120 kg/ha NPS and 45 kg/ha Urea at the Delbo site. In contrast, at the Soddo location, the largest root diameter of 2.3 cm was achieved with 120 kg/ha NPS and 135 kg/ha Urea, while the highest root dry weight per plant of 3.3 g was found at 0 kg/ha NPS and 0 kg/ha Urea. Furthermore, the greatest root weight per plant of 29.0 g and the root yield of 32,333 kg/ha were both noted at 120 kg/ha NPS with no Urea applied (Table 2).

The smallest root diameter recorded was 1.8 cm, observed at both 60 kg/ha NPS and 0 kg/ha. Additionally, the lowest values for root fresh weight per plant (14.9 g), root yield (8,567 kg/ha), and root dry weight per plant (0.7 g) were noted at 0 kg/ha NPS and 0 kg/ha Delbo. In Soddo, the minimum root diameter (1.8 cm), root fresh weight (15.1 g), and root yield (15,071 kg/ha) were also found at 0 kg/ha NPS

combined with 90 kg/ha. Conversely, the least root dry weight (1.3 g) was recorded at 180 kg/ha NPS and 45 kg/ha Urea (Table 2). Overall, an increase in fertilizer application generally led to enhanced yield parameters, although this trend was not uniform. The growth and yield of plants are significantly affected by nitrogen uptake and its biochemical conversion; thus, a higher nitrate reduction to ammonium at 75 kg/ha may have contributed to improved carrot yields by facilitating greater nitrogen allocation to photosynthesis and carbon metabolism in the plants [6]. This finding aligns with the observations of previous studies [8, 17], which noted that the increase in root size or mass corresponds with higher fertilizer levels, particularly nitrogen, which is known to enhance plant growth and yield. Furthermore, it was established that the fresh weight of roots was significantly affected by both nitrogen dosage and plant variety [1]. Other research indicated that root fresh weight increased with rising fertilizer levels up to a certain threshold before declining [7]. Additionally, it was found that average root weight, root length, and yield improved with increasing fertilizer application rates, specifically up to 40 kg N + 36 kg P<sub>2</sub>O<sub>5</sub> + 49 kg K<sub>2</sub>O per feddan [11].

**Table 2.** Effect of fertilizer rate (kg/ha) on yield and yield attributes of carrot.

NPS rate	Delbo					Soddo			
	Urea rate	RD	RDWPP	RWPP	RY	RD	RDWPP	RWPP	RY
0	0	1.9ab	0.7h	14.9f	8567e	2.2ab	3.3a	25.8abc	25800b
	45	2.2ab	2.0de	23.9cd	23867bc	2.0ab	2.8bc	20.2cde	20200cde
	90	2.0ab	1.3g	22.7cd	22667bc	1.8b	3.1abc	15.1e	15071e
	135	1.9ab	2.5abcd	20.6de	20600cd	1.8b	3.1ab	15.3e	15333e
60	0	1.8b	2.3bcde	17.5ef	17467d	2.3a	2.0ef	24.1abcd	24067bcd
	45	2.2ab	2.6abc	23.9cd	23933bc	2.0ab	1.8efg	18.8de	18800de
	90	2.4a	2.4bcde	31.3a	31330a	2.1ab	3.1abc	19.9cde	19933de
	135	2.2ab	1.9ef	30.8a	30833a	2.1ab	1.9ef	23.3abcd	23267bcd
120	0	2.3ab	2.7abc	23.5cd	23467bc	2.3a	2.9abc	25.5abc	25467bc
	45	1.9ab	2.9a	21.7cde	21733bc	2.4a	2.7bcd	26.7ab	26700b
	90	2.2ab	2.2cde	25.5bc	24867b	2.1ab	2.6cd	20.5bcde	18867de
	135	2.1ab	1.5fg	21.8cde	22467bc	2.3a	1.5fg	26.1abc	27800ab
180	0	2.0ab	2.3cde	22.5cd	22533bc	2.1ab	1.9ef	29.0a	32333a
	45	2.2ab	0.8h	29.7ab	29733a	2.1ab	1.3g	27.0a	27000b
	90	2.4ab	2.7abc	31.3a	31333a	2.2ab	1.8ef	23.2abcd	23200bcd
	135	2.2ab	2.8ab	30.3a	30333a	2.3a	2.2de	25.7abc	25733b
LSD (0.05)		0.6	0.5	4.6	3892.9	0.4	0.5	6.3	5307.7
CV (%)		16.6	13.5	11.2	9.7	11.5	19.5	17.1	15.8

Means followed by the same letter with in the column are not different from each other at  $P=0.05$  level of significance. Where, RD = root diameter (cm), RDWPP = root dry weight per plant (g), RWPP (g) = root weight per plant and RY = root yield (kg/ha).

The influence of varying rates of NPS and Urea on shelf life, marketable yield, and root water content was found to be statistically significant ( $P < 0.05$ ) at both the Delbo and Soddo locations, as well as for core diameter per plant at Soddo, although it was not significant at Delbo. At Delbo, the optimal shelf life of 20.0 days was achieved with 60 kg/ha of NPS and 135 kg/ha of Urea, while the highest marketable yield of 31,333 kg/ha was recorded with 180 kg/ha of NPS and 90 kg/ha of Urea. Additionally, the total soluble solute content reached 9.89% with 60 kg/ha of NPS and no Urea, and root water content was measured at 96.5% with 180 kg/ha of NPS and 45 kg/ha of Urea. In contrast, at Soddo, the longest shelf life of 24.0 days was noted with no application of NPS or Urea, the highest marketable yield of 27,800 kg/ha was obtained with 120 kg/ha of NPS and 135 kg/ha of Urea, total soluble solute content peaked at 11.2% with no NPS and 135 kg/ha of Urea, and root water content was recorded at 91.9% with 180 kg/ha of NPS and 90 kg/ha of Urea. The core diameter per plant reached 0.80 cm with 60 kg/ha of NPS and no Urea (Table 3).

The shortest shelf life recorded was 13.0 days with 0 kg/ha NPS and 90 kg/ha Urea, while the list marketable yield of 14,867 kg/ha was achieved with both 0 kg/ha NPS and 0 kg/ha Urea. Additionally, the lowest total soluble solute content reached 6.0% at 120 kg/ha NPS and 45 kg/ha Urea, and the root water content was measured at 83.4% with 60 kg/ha NPS and 0 kg/ha Urea, all observed at Delbo (Table 3). In contrast, at Soddo, the lowest shelf life of 17.0 days and a marketable yield of 15,067 kg/ha were noted with 0 kg/ha NPS and 90 kg/ha Urea. The total soluble solute content was 6.6% at 180 kg/ha NPS and 0 kg/ha Urea, while the list root water content was 79.0%, and the core diameter per plant measured 0.57 cm at the combination of 0 kg/ha NPS and 135 kg/ha Urea (Table 3).

Overall, an increase in fertilizer application generally led to enhanced marketable yield and shelf life, although this trend was not uniform. This finding aligns with the observations made by [9], which indicated that raising nitrogen fertilizer levels to 180 kg/ha boosts marketable yield. Similar conclusions were drawn by [25]. Furthermore, [7] noted that



varying fertilizer levels had a slight yet significantly positive impact on the total soluble solids content in carrots.

**Table 3.** Effect of fertilizer rate (kg/ha) on quality parameters of carrot.

NPS rate	Delbo					Soddo				
	Urea rate	SL	MY	TSS	RWC	SL	MY	TSS	RWC	CDPP
0	0	14.0ab	14867g	8.2ab	88.9ab	24.0a	25467ab	8.8abcd	87.1abc	0.7ab
	45	17.0ab	21467cde	7.8ab	90.4ab	19.7abcd	17667ef	8.8abcd	87.0abc	0.7abc
	90	13.0b	21733cde	6.8ab	93.8ab	17.0d	15067f	10.9ab	79.9cd	0.6bc
	135	17.0ab	20067e	8.8ab	87.2ab	17.0d	19400cdef	11.2a	79.0d	0.6c
60	0	17.0ab	17267f	9.9a	83.4b	21.7abc	24067abc	7.7cd	90.5ab	0.8a
	45	20.0a	23933b	8.2ab	89.0ab	19.7abcd	17200f	7.8cd	90.3ab	0.7abc
	90	17.0ab	31130a	7.5ab	91.4ab	18.3cd	19933cdef	9.6abc	84.2bcd	0.7abc
	135	20.0a	23467bc	7.4ab	91.8ab	23.0ab	23267abcd	7.5cd	91.4ab	0.7abc
120	0	14.0ab	23467bc	8.3ab	88.7ab	21.7abc	25467ab	8.6bcd	87.8ab	0.8a
	45	15.0ab	21733cde	9.1ab	86.0ab	21.7abc	26700ab	8.0cd	89.7ab	0.8a
	90	17.0ab	23600bc	8.0ab	89.9ab	22.0abc	18533def	8.9abcd	86.8abc	0.7abc
	135	15.0ab	21600cde	7.0ab	93.1ab	21.7abc	27800a	6.6d	94.2a	0.8a
180	0	15.0ab	20867de	8.7ab	87.5ab	23.0ab	25667ab	6.6d	94.3a	0.7abc
	45	14.0ab	22900bcd	6.0b	96.5a	21.7abc	27000ab	9.6abc	89.8ab	0.7abc
	90	17.0ab	31333a	7.4ab	91.5ab	19.33bcd	22533bcde	7.4cd	91.9a	0.7ab
	135	20.0a	30333a	9.1ab	86.0ab	24.0a	24200abc	7.9cd	90.0ab	0.7ab
LSD (0.05)		6.0	2141.1	3.7	13.1	12.4	5047.4	2.5	9.3	0.2
CV (%)		22.0	5.6	28.0	8.3	12.5	15.6	17.6	5.4	12.8

Means followed by the same letter with in the column are not different from each other at P=0.05 level of significance. Where, SL = shelf life (days) MY = marketable yield, TSS = total soluble solute, RWC = root water content (%) and CDPP = core diameter per plant.

## 4. Conclusion

Overall, the root length per plant, leaf length per plant, and core diameter per plant at Delbo were not significantly influenced by the fertilizer rate. However, other growth, yield, and quality parameters were notably affected by the interaction between NPS and Urea fertilizer rates. Although this study was conducted over a single season, it clearly demonstrated that fertilizer rates had a significant impact on the growth and productivity of carrots. Utilizing a fertilizer rate of 180 kg/ha NPS and 90 kg/ha Urea at Delbo, as well as 120 kg/ha NPS and 135 kg/ha Urea at Soddo, showed promise for enhancing carrot productivity in the experimental area and similar environmental conditions. Nonetheless, additional research across different seasons is necessary to validate these findings.

## Abbreviations

CSA	Central Statistical Authority
LSD	Least Significant Difference
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
TSS	Total Soluble Solids
WC	Water Content

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## Author Contributions

**Abdirshikur Reshid Jemal:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Software

**Zekiya Fitret Shikur:** Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software

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## Conflicts of Interest

The author declares no conflicts of interest.

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