



# Study Growth, Root Yield and Yield Related Character of Carrot (*Daucus carrota*) Varieties under Highland Areas of Southern Tigray Region, Northern Ethiopia

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## ABSTRACT

Carrot (*Daucus carrota* L.) is a widely grown and nutritious root vegetable of the Apiaceae family grown in different countries of the world. While, the production and productivity of this crop is restrained by different factors; of which lack of evenly distributed improved and adapted varieties are the major one. Thus, the experiment was conducted to evaluate the performance of carrot varieties in 2017 and 2018 at Endamehoni woreda of Southern zone of Tigray region. As a treatment different varieties were assigned in RCBD with three replications. Data on plant height (cm), leaf number, leaf weight (gm), root length (cm), root diameter (cm) and root yield in terms of ton per hectare were collected and analyzed using SAS software version 9.3. In 2017 plant height and leaf weight plant<sup>-1</sup> were highly significantly ( $p < 0.01$ ) influenced by carrot cultivars. In the same year, root length, root diameter and root yield were significantly ( $p < 0.05$ ) affected by carrot cultivars in the study area. In 2018 plant height and leaf weight plant<sup>-1</sup> were highly significantly influenced by carrot cultivars in both locations. Root length was highly significantly ( $P < 0.01$ ) influenced by the cultivars at Embahasti location. In the same cropping season root diameter was highly significantly ( $P < 0.01$ ) and significantly ( $p < 0.05$ ) affected by carrot cultivars at Embahasti and Maichew locations respectively. Root yield was highly significantly ( $P < 0.01$ ) affected by carrot cultivars at Maichew location. In 2017 cropping season, both the highest root length (21.72 cm) and root diameter (3.94 cm) was obtained from DzARC-5 cultivar. Similarly in 2018 cropping season, the highest root length (18.79 cm) was recorded from DzARC-5 variety at Embahasti location. The widest root diameter (3.17 cm) and (3.94 cm) was taken from DzARC-5 and AUA-108 varieties at Embahasti and Maichew locations respectively. In 2017, the maximum root yield (47.96-ton ha<sup>-1</sup>) was recorded from DzARC-5 cultivar. However, in 2018 cropping season, the maximum (38.79-ton ha<sup>-1</sup>) root yield hectare<sup>-1</sup> was recorded from AUA-108 cultivar. Overall, DzARC-5 which gave maximum root yield ha<sup>-1</sup> (47.96-ton ha<sup>-1</sup>) is recommended at Maichew. Since there is no significant variation on root yield among carrot varieties at Embahasti area, it is important to repeat the experiment at this location by including other carrot cultivars. Further, it is important to investigate the influence of spacing (intra and interspacing) on the yield and morphological quality of the carrot.

**Keywords:** Carrot cultivars, cropping season, location, root yield

## 1. INTRODUCTION

Carrot (*Daucus carota*) is one of the root vegetable crops which is grown worldwide for its therapeutic and nutritional properties (Fanlégué *et al.*, 2017). It belongs to apiaceae family and is a cool season biennial cultivated as an annual crop in the tropics (De Lannoy, 2001). Studies indicated that the domesticated carrot was first originated in Central Asia (Iorizzo *et al.*, 2013; Iorizzo *et al.*, 2020). Its wild ancestors probably originated in Persia (regions of which are now Iran and Afghanistan), which remains the centre of diversity for the wild carrot. In many nations, carrots provide a significant source of alpha- and beta-carotene, the building blocks of vitamin A. (Speizer *et al.*, 1999). It is also a significant source of vitamins, minerals, polyacetylenes, carotenoids, and flavonoids, all of which have a variety of nutritional and physiological advantages (Silva Dias, 2014). Furthermore, carrot can provide paramount of vitamin A better than other vegetables due to the high bioavailability of carrot carotenoids (van *et al.*, 2000). Carrot can be used as salad, cooked vegetable and in juices (Sharma *et al.*, 2020). Besides being food, different parts of the crop can be utilized for different medicinal purposes like curing kidney diseases (Anjum and Amjad, 2002).

Even though, the exact time of carrot introduction to Ethiopia is not known, research on carrot was started early in 1960s at Alemaya College of Agriculture (now Haramaya University) (Kifle-Iyesus, 1994; Kidanemariam, 1969). Currently, some varieties adaptation and carrot management trials have been conducted at some part of Ethiopia. However, there are gaps on carrot technologies and information availability particularly shortage of high yielder variety, agronomic and irrigation aspects in most parts of Ethiopia. Particularly in Tigray regional state, this crop is less considered under research system; but the community are growing accessions (unimproved varieties) for home consumption and marketing purpose. So it is necessary to supplement the production of carrot by research in order to boost the productivity and production of carrot. Before goes to solving other problems, evaluating performance of carrot varieties to come up with most performing and adaptable variety/ies is/are crucial. Thus, the

objective of this study is to study the performance of carrot varieties at Endamehoni district of Southern Tigray Zone.

## 2. MATERIAL AND METHOD

### 2.1. Description of the Experimental Site

A field experiment was conducted for two consecutive years (2017 and 2018) under rain fed condition at Endamehoni district of Tigray regional state.

### 2.2. Experimental Procedure

#### 2.2.1. Experimental Materials

Four carrot varieties: DzARC-5, AUA-108, DzARC-9 and Nantes were brought from Debrezeit Agricultural Research Center were used for the experiment.

#### 2.2.1. Land preparation, Treatment arrangement and Experimental Design

Before planting, the area was cleared, tilled, and leveled to achieve ideal growing conditions. The experimental was divided into three identical groupings called block. According to RCBD principle, each treatment was assigned in a block once and repeated three times in the whole experiment. Each plot has 1.5 m x 1.25 m (1.875 m<sup>2</sup>) in size, with 1 m and a 0.5 m separation between blocks and plots respectively. Space between rows and plants were separated by 0.25 and 0.1 meters respectively. Crop management practices like cultivation and weeding were carried out in accordance with the needs. NPSB and urea fertilizer were applied during the trial period in accordance with the suggested rate (100 kg NPSB and 100 kg urea/ha). NPSB was used when panting, but urea was applied half at planting time and the remaining half at mid stage of the crop

### 2.4. Data Collected

Growth and yield data like plant height (cm), leaf weight (gm), leaf number, root length (cm), root diameter (cm) and root yield (ton per hectare) were collected properly

### 2.5 Data Analysis

Data were analyzed using SAS software (9.3 version). For those parameters showed significance difference, mean separation was done using List Significant Difference (LSD) at 5% probability level..

### 3. RESULT AND DISCUSSION

#### 3.1. Plant Height, Leaf number and Leaf Weight per Plant

At both Embahasti and maichew locations, plant height and leaf weight per plant were highly significantly ( $P < 0.01$ ) influenced by carrot cultivars in 2017 and 2018 production season (Table 5 and 6). In 2018 cropping year, leaf number per plant was significantly affected by the cultivars from both locations (Table 6).

DzARC-9 variety gave the tallest plant height (55.54 cm) which is significantly similar with AUA-108 and DzARC-5 varieties, while the shortest plant height was noted on Nantes variety in 2017 cropping season. In this cropping season, DzARC-5 variety showed the highest leaf weight plant<sup>-1</sup> (85.24gm). Nevertheless, this cultivar didn't show significant different from DzARC-9. The lowest leaf weight plant<sup>-1</sup> was recorded at Nantes variety with average values of 8.52gm (Table 1).

In 2018 cropping season, the tallest plant height was observed at variety DzARC-5 (50.99 cm), AUA-108 (43.74 cm), DzARC-5 (53.80 cm) and AUA-108 (54.21 cm) at Embahasti and Maichew respectively. However, there was no significance difference between AUA-108 and DzARC-5 on plant height. In this production year, the maximum leaf number plant<sup>-1</sup> was recorded on DzARC-5 (12.08) and AUA-108 (15.59) varieties at Embahasti and Maichew locations respectively (Table 3).

#### 3.1. Root length, Root Diameter and Root Yield

At Maichew, root diameter and root length were highly significantly ( $p < 0.01$ ) influenced by carrot cultivars in 2017 production year (Table 5). In 2018 year, root length was highly significantly ( $p < 0.01$ ) influenced by varieties at Embahasti location but non significance response was observed at Maichew location. Root diameter of carrot was significantly ( $p < 0.05$ ) affected by carrot cultivars at both Embahasti and Maichew locations. Root yield was highly significantly ( $p < 0.01$ ) affected by carrot varieties at Maichew (Table 7).

**Table 1 . Mean performance of Carrot varieties for vegetative growth in 2017 cropping season at Maichew**

VAR	Plant height(cm)	Leaf Number/ plant	Leaf Weight/plant (gm )
DzARC-9	55.54a	14.30	69.52a
AUA-108	46.97a	12.41	31.63b
DzARC-5	53.97a	11.93	85.24a
Nantes	28.56b	7.48	8.52c
Mean	46.23	11.53	48.73
CV(%)	9.69	29.17	18.64
LSD	8.95	NS	18.15

NS = non-significant at  $p \geq 0.05$ , Means within columns for each variable followed by different letters are statistically different from each other at ( $p < 0.05$ ), Var=Variety

**Table 2. Mean performances of Carrot varieties for yield and yield related traits at Maichew during 2017 cropping season**

VAR	Root Length(cm)	Root Diameter(cm)	Root Yield ton/ha
DzARC-9	21.34a	2.80b	31.67ab
AUA-108	17.31b	2.91b	31.76ab
DzARC-5	21.72a	3.94a	47.96a
Nantes	13.10c	1.93c	13.67b
Mean	18.31	2.90	31.27
CV(%)	9.65	13.75	30.79
LSD	3.54	0.80	19.24

NS = non-significant at  $p \geq 0.05$ , Means within columns for each variable followed by different letters are statistically different from each other at ( $p < 0.05$ ), Var=Variety.

**Table 3. Mean performance of Carrot varieties for growth traits at Different location during 2018**

VAR	Plant height(cm)			Leaf Number/ plant			Leaf Weight/plant(gm)		
	Locations								
	Embahasti	Maichew	Mean	Embahasti	Maichew	Mean	Embahasti	Maichew	Mean
AUA-108	43.74 <sup>a</sup>	54.21 <sup>a</sup>	48.98	9.50 <sup>ab</sup>	15.59 <sup>a</sup>	12..55	29.22 <sup>b</sup>	85.04 <sup>a</sup>	57.13
DzARC-5	50.99 <sup>a</sup>	53.80 <sup>a</sup>	52.40	12.08 <sup>a</sup>	11.36 <sup>b</sup>	11.72	73.82 <sup>a</sup>	80.55 <sup>a</sup>	77.19
Nantes	30.43 <sup>b</sup>	42.56 <sup>b</sup>	36.50	8.50 <sup>b</sup>	10.58 <sup>b</sup>	9.54	11.57 <sup>c</sup>	27.28 <sup>b</sup>	19.43
Mean	41.70	50.19		10.03	12.51		38.20	64.29	
CV(%)	13.05	6.10		15.79	13.11		12.88	12.54	
LSD	9.42	3.30		2.74	2.84		8.51	13.94	

NS = Non-significant at  $p \geq 0.05$ , Means within columns for each variable followed by different letters are statistically different from each other at ( $p < 0.05$ ), VAR=Variety

**Table 4. Mean performances of Carrot varieties for yield and yield related traits at Different location during 2018**

VAR	Root Length(cm)			Root Diameter(cm)			Root Yield Ton/ha		
	Locations								
	Embahasti	Maichew	Mean	Embahasti	Maichew	Mean	Embahasti	Maichew	Mean
AUA-108	16.67 <sup>ab</sup>	21.40	19.04	2.81 <sup>b</sup>	3.94 <sup>a</sup>	3.38	24.14	38.79 <sup>a</sup>	31.47
DzARC-5	18.79 <sup>a</sup>	17.33	18.06	3.17 <sup>a</sup>	2.85 <sup>b</sup>	3.01	24.28	19.73 <sup>c</sup>	22.01
Nantes	14.36 <sup>b</sup>	19.58	16.97	2.52 <sup>b</sup>	3.39 <sup>ab</sup>	2.96	18.42	30.77 <sup>b</sup>	24.60
Mean	16.61	19.44		2.83	3.39		20.95	29.76	
CV(%)	9.08	13.77		6.96	11.45		16.58	7.39	
LSD	2.61	NS		0.34	0.67		NS	3.80	

NS = Non-significant at  $p \geq 0.05$ , Means within columns for each variable followed by different letters are statistically different from each other at ( $p < 0.05$ ), Var=Variety

**Table 5. Mean squares of Carrot varieties for Growth, yield and yield related traits in 2017 Cropping Season at Maichew**

SOV	DF	PH(cm)	Leaf Number/ plant	Leaf Weight/ plant(gm)	Root Length(cm)	Root Diameter	Root Yield Ton/ha
Block	2	10.09	14.53	87.58	8.61	0.16	151.41
Trt	3	459.22**	NS	3675.18**	48.85**	2.03**	588.47*
Error	6	20.08	11.31	82.49	3.14	0.16	92.69
CV(%)		9.69	29.17	18.64	9.65	13.75	30.79

**Note:** DF= Degree freedom; SOV= Source of Variation, PH =Plant height

**Table 6. Mean squares of Carrot varieties for Growth, yield and yield related traits at different location during 2018 Cropping Season**

SOV	DF	Locations					
		PH(cm)		Leaf Number/ plant		Leaf Weight/ plant(gm)	
		Embahasti	Maichew	Embahasti	Maichew	Embahasti	Maichew
Block	2	2.29	10.09	8.33	4.59	16.76	87.58
Trt	3	435.27**	459.22**	13.68*	28.98*	4116.66**	3675.18**
Error	6	29.65	20.08	2.51	2.69	24.20	82.49
CV(%)		13.05	9.69	15.79	13.11	12.88	18.64

**Note:** DF= Degree freedom; SOV= Source of Variation, PH =Plant height

**Table 7. Mean squares of Carrot varieties for Growth, yield and yield related traits at different location in 2018 Cropping Season**

SOV	DF	Locations					
		Root Length(cm)		Root Diameter(cm)		Root Yield ton/ha	
		Embahasti	Maichew	Embahasti	Maichew	Embahasti	Maichew
Block	2	1.79	2.68	0.04	0.02	15.65	3.23
Trt	3	19.64**	NS	0.42**	1.18*	NS	366.58**
Error	6	2.28	7.16	0.39	0.15	13.60	4.83
CV(%)		9.08	13.77	6.96	11.45	16.55	7.39

**Note:** DF= Degree freedom; SOV= Source of Variation

In 2017 production season, the highest root length (21.72 cm) and root diameter (3.94 cm) was obtained from DzARC-5 variety at Maichew. While the lowest root length (13.10 cm) was recorded from Nantes cultivar. In the same cropping season, the widest (3.94cm) and narrowest average root diameter (1.93) was noted on DzARC-5 and Nantes cultivar respectively. Similarly, the maximum root yield  $\text{ha}^{-1}$  (47.96-ton  $\text{ha}^{-1}$ ) was recorded from DzARC-5 variety at this location which is non-significant with DzARC-9 and AUA-108 varieties. (Table 2).

In 2018 cropping season, significantly the highest root length (18.79) was recorded at Embahasti from DzARC-5 variety which is statistically similar with AUA-108 (16.67 cm) variety. While the lowest root length was obtained from Nantes (14.36 cm) variety. This character is not significantly affected carrot varieties at Maichew location. Carrot varieties were statistically influence root diameter both at Embahasti and Maichew locations. The highest (3.94 cm) and the lowest (2.85 cm) root diameter was recorded from AUA-108 and DzARC -5 variety at Maichew location. At Embahasti, DzARC-5 variety gave the widest root diameter (3.17 cm) while Nantes gave the narrowest root diameter (2.52 cm) which is non-significant with AUA-108 variety. These all shows us even one carrot variety perform differently in different area in one cropping season and also show different performance at one location in different cropping season. So, different areas require different carrot variety (Table 4).

In 2018 cropping season, significantly the maximum (38.79 ton  $\text{ha}^{-1}$ ) root yield hectare<sup>-1</sup> was observed on AUA-108 variety, while the minimum value of root yield (19.73 ton  $\text{ha}^{-1}$ ) was recorded from DzARC-5 variety at Maichew Location (Table 4). At Embahasti, the carrot varieties were not affect root yield hectare<sup>-1</sup> significantly. Based on the results obtained, Maichew area is more congenial for carrot production whereby the maximum average root yield (29.76 ton  $\text{ha}^{-1}$ ) of the three varieties where obtained there. In case of variety, AUA-108 variety performs well relatively across the two locations which gave average root yield of 31.47 ton  $\text{ha}^{-1}$  in 2018 cropping season (Table 4). This indicates that the performances of carrot varieties are the combined effect of environmental factors (location) and the genotypic features of variety. Thus, the performance of a particular variety varies with

location and season of production. So, a variety is location and season specific.

## CONCLUSION

The study was carried out from 2017 to 2018 years under rain fed condition at Embahasti and Maichew areas of Tigray regional state. The result revealed that, plant height and leaf weight plant<sup>-1</sup> were highly significantly ( $p < 0.01$ ) influenced by carrot cultivars in 2017 cropping season. Likewise, root length and root diameter were highly significantly ( $P < 0.01$ ) influenced by the cultivars in the study area. Root yield ton hectare<sup>-1</sup> was significantly ( $P < 0.05$ ) affected by carrot cultivars at Maichew. In 2018, root length was highly significantly influenced by carrot varieties only at Embahasti. Root diameter was significantly affected by the cultivars at Maichew and Embahasti. Root yield was significantly affected by the studied varieties only at Maichew location.

DzARC-9 variety gave the maximum plant height (55.54 cm) in 2017 cropping year. DzARC-5 variety showed the maximum leaf weight plant<sup>-1</sup> at Maichew areas with leaf weight plant<sup>-1</sup> of 85.24 gm. The tallest plant height was recorded from variety DzARC-5 (50.99 cm), AUA-108 (43.74 cm), DzARC-5 (53.80 cm) and AUA-108 (54.21) at Embahasti and Maichew respectively in 2018 cropping season. The highest leaf number plant<sup>-1</sup> was obtained from DzARC-5 (12.08) and AUA-108 (15.59) at Embahasti and Maichew respectively in 2018 cropping season. In 2017 cropping season, both the highest root length (21.72 cm) and root diameter (3.94 cm) were recorded from DzARC-5 variety at Maichew. The maximum root yield  $\text{ha}^{-1}$  (47.96-ton  $\text{ha}^{-1}$ ) was also obtained from DzARC-5 variety.

In 2018 cropping season, significantly the highest root length (18.79) was recorded at Embahasti from DzARC-5 variety. DzARC-5 and AUA-108 carrot varieties gave the widest root diameter (3.17 cm) and (3.94 cm) at Embahasti and Maichew respectively. The maximum (38.79 ton  $\text{ha}^{-1}$ ) root yield hectare<sup>-1</sup> was recorded on AUA-108 variety at Maichew location in the same cropping season. However, in 2017 production year, DzARC-5 variety gave the maximum root yield  $\text{ha}^{-1}$  (47.96-ton  $\text{ha}^{-1}$ ) at Maichew and so; this variety is tentatively recommended at Maichew areas. Since there is no significant among carrot varieties at Embahasti area, it is important to repeat the

experiment at this location by including other carrot cultivars.

**Conflict of Interest:** None of the authors have any conflicts of interest to disclose. All the authors approved the final version of the manuscript.

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