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# Evaluation of Carrot (*Daucus carota* Var.Sativa) Varieties for Yield and Related Traits under Wondo Genet and Negelle Arsi Conditions

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**Abstract:** Carrot is one of important root crops widely produced for its economic importance. However, most farmers in the study area produce the cultivars which are not well known, poor in disease resistance and low yielder per unit areas. To alleviate this constraint, the field experiment was conducted at Wondo Genet and Negelle Arsi for consecutive of two years. Two carrot (Haramaya-I and one imported commercial variety [Nantes]) varieties were used and laid down in Randomized Complete Block Design (RCBD) with four replications. Data on yield components and root yield related parameters were collected for both locations over two years and analyzed using SAS (version 9.4) and excel software. The analysis of variance revealed that the root core diameter, root length, root weight and unmarketable root yield were influenced by the varieties. Thus, maximum root core diameter (2.86cm), root length (12.83cm), root weight (49.64g) and unmarketable root yield (2.01 t $ha^{-1}$) were recorded from Haramaya-I variety. The interaction of year and locations (environment) was also significantly affected the root diameter, marketable and total root yield of carrot. Hence, the highest root diameter (2.88 cm) was observed at Wondo Genet area in 2020 whereas the highest marketable root yield (29 t $ha^{-1}$) and total root yield (31.56 t $ha^{-1}$) were observed at Negelle Arsi area in 2019. Furthermore, the interaction of varieties and locations were also affected the root diameter, root length and unmarketable root yield of carrot varieties. So, in production of carrot considering the environment and season (year) of production in addition to varietal selection is important.

**Key words:** Environment · Interaction · Location · Root Yield

## INTRODUCTION

Carrot (*Daucus carota* var. *sativa*) is the most important root crop of Apiaceae family which widely distributed worldwide. It is originally wild in many parts of Europe and Asia and was first domesticated in Afghanistan, considered as the primary center of diversity and Turkey is believed as a second center of diversity. From the center of diversity, it was spread over Europe, the Mediterranean and Asia countries and has been introduced with local wild types during spread over the world [1]. The domestic carrot is a cool season biennial plant that grows a rosette of leaves in the spring and summer while building up the stout taproot, which stores large amounts of carbohydrates for the plant to flower in the second year. The flowering stem grows to about 1 m tall, with an umbel of white flowers. The roots are greatly enlarged and sweet with good storage ability [1].

Carrot roots are source of carotenoids, precursors of vitamin A [2], rich in pro-healthy antioxidants both of lipophylic (carotenoids) and hydrophilic (phenolic compounds) characters [3]. It also contains carotenoids, flavonoids, vitamins and minerals thus making the crop rich source of nutrition that is essential for good health [4]. In Ethiopia, the carrot roots are used in a daily diet as vegetable for salad, soups and stews [2].

It is one of the most important root vegetables grown in the world, which production has increased recently. Carrot is the cool season root vegetable which can tolerate some tropical climates. Yield and quality characteristics of carrots benefit from cooler growing conditions (10 to 15°C). At temperatures above 25°C during storage root formation, the respiration rate of the plant increases, resulting in lower yields [5]. Carrot yields and root length were also influenced by the water content during the vegetative period [6]. Suojala [7] reported that

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low precipitation at the end of the growing season may promote dying of the oldest leaves. Furthermore, low soil moisture will force the plants to invest in root extension growth rather than storage root development resulting in a reduction in root yield [8].

The exact time of introduction of carrot to Ethiopia is not well known [9], but currently it is one of the widely produced and consumed root vegetables in Ethiopia [4]. According to CSA [10] reported from the total area allocated for vegetable production in Ethiopia, about 1.1 % was covered by carrot with101, 48.23 tons of root yield was harvested. Nowadays the consumption rate of carrot is increasing due to its vitamin A contribution especially around urban areas of the country. However, absence of improved carrot varieties which is suitable for all climate condition is the main bottle neck problem of the crop production in the country. Even though, a high production demand and a little production trend is observed in some parts of the country, its distribution and production has not been adequately exploited due to it is confronted by a number of constraints like absence of well adapted cultivars, inappropriate agronomic practices, disease and problem of post-harvest handling techniques.

Carrot production is highly practiced and feed the local markets (Hawassa and Shashemene towns) and also transported to national market, Addis Ababa from the study areas. Even though the crop is produced in large amount there is lack of improved varieties that has been adapted to the areas under production. However, in eastern part of Ethiopia, Haramaya-I variety was released by Haramaya University which performs better than farmers variety [9]. The released carrot variety was found to be superior in marketable and total root yields and other desirable traits to the commercial Nantes variety [9]. Since, unlikely that one of many potential new cultivars will be best in all environments and for all uses; then, assessment of Genotype × Environment interactions can be analyzed and visualized through a principal component to determine the stability [11]. Hence, to advance improvement of crop productivity in different localities, continual identification of the best and suitable crop technologies appeared to be essential. This can be achieved, through adaptability tests and generation of the new technologies. Therefore, this research study was designed in such a way that adaptability of already existing carrot technologies has been tested for their suitability with the objective of evaluating the performance of Haramaya-I variety over the commercial Nantes variety at Wondo Genet and Negelle Arsi agro ecological areas.

## MATERIALS AND METHODS

The evaluation was conducted during the 2019 and 2020 cropping seasons for two consecutive years at Wondo Genet Agricultural Research Center (WGARC), Sidama region and Negelle Arsi, west Arsi zone of Oromia region during the main season under rain fed condition. WGARC is located at 07° 19.1' N and 38° 38' E at the elevation of 1780 m.a.s.l. The area receives a mean annual rainfall of 1128 mm with minimum and maximum temperature of 12.02 and 26.72°C respectively. Negelle Arsi is also located at 7°05'N and 39°29'E at the elevation of 1895 m.a.s.l. The area receives a mean annual rainfall of 964 mm with minimum and maximum temperature of 12.94 and 27.34°c, respectively. At both locations the experiment was replicated in two years of 2019 and 2020.

The treatments (two carrot varieties) were randomly assigned to each plot and the experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications at the sites of both areas. The experiment had a total area of 148.5 $m^2$ (9m length and 16.5m width) with a plot area of 12$m^2$ (4m length and 3m width). The spacing between blocks and plots was maintained at 1.5m and 1m, respectively. Each plot consisted of 15 rows and 80 plants per row. The seeds of carrot varieties namely; Haramaya-I (obtained from Holleta Agricultural Research Center) and Nantes (purchased from Shashemene local market) were drilled on the well prepared soils of each plot by keeping specified rows of 20 cm inter row spacing. After the seedling was reached a height of 5 cm, it has been tinned into one plant per stand by keeping 5cm intra row spacing. Then, all required agronomic management practices like weeding, hoeing and fertilizer application (NPS and Urea) were applied uniformly to all experimental plots. Then, the data on growth, yield components and root yield parameters were carefully collected from plants in the middle rows per plot that constituted the net plot size of 1$m^2$ has been used for sampling and further data analysis.

**Data Analysis:** Data recorded for growth, yield components and root yield parameters were subjected to Analysis of Variances (ANOVA) to test the significant effects of varieties, locations, years and their interactions. Then, the collected data were subjected to analysis of variance using the General Linear Model (GLM) of the Statistical Analysis System (SAS) software version 9.4. Least Significant Difference (LSD) at 5% probability was used for mean separation when analysis of variance indicated the presence of significant differences. Also, the excel software was used to compare the two varieties.

## RESULTS AND DISCUSSION

The combined effects of two years mean analysis showed that there were significant differences between the two carrot varieties for root core diameter, root length, single root weight and unmarketable root yield per hectare (Table 1). While marketable and total root yield per hectare were not significantly influenced by the varieties. The highest root core diameter, root length and single root weight were obtained from Haramaya-I and the lowest was observed for Nantes variety. The lowest unmarketable root yield was observed for Nantes and the highest was for Haramaya-I varieties. The significant differences observed between the two varieties might be due to the genotypic difference of carrot varieties. These differences indicated that the presence of variability and considerable opportunity for the crop characteristic improvement purpose.

Also, locations were significantly affected the carrot marketable and unmarketable root yields (Table 2). Hence, the highest marketable root yield (23.11tha$^{-1}$), unmarketable root yield (2.01tha$^{-1}$) and total root yield (25.12tha$^{-1}$) were obtained at Negelle Arsi and the lowest were from Wondo Genet. The difference of environmental areas can affect growth and yield of carrot. The micro-climate of the soil is essential in the development of carrot root yield and soil temperature plays a great role in the development of root growth and weight yield. Wheeler *et al*. [12] reported that 1°C rise in mean soil temperature increased total weight by 37% and root weight by 34% at 134 days after sowing.

Suojala [7] also reported that low rainfall at the end of the growing season may promote dying of he leaves which decrease photosynthesis activities that aggravate yield decrement. Additionally, unbalanced soil moisture will force the plants to invest in root extension growth

Table 1: The overall varieties mean performance of the two carrot varieties evaluated during 2019 and 2020 cropping season

| Varieties | Root Core Diameter (cm) | Root Length (cm) | Root Weight (g) | Marketable Yield (tha$^{-1}$) | Unmarketable Yield (tha$^{-1}$) | Total Yield (tha$^{-1}$) |
|---|---|---|---|---|---|---|
| Haramaya-I | 2.86$^{a}$ | 12.83$^{a}$ | 49.64$^{a}$ | 19.02 | 2.01$^{a}$ | 21.09 |
| Nantes | 2.14$^{b}$ | 9.57$^{b}$ | 35.28$^{b}$ | 19.93 | 1.35$^{b}$ | 21.29 |
| $LSD_{0.05}$ | 0.26 | 1.46 | 7.62 | ns | 0.47 | ns |

Means followed by the same letter with in the same column are statistically non-significant at P < 0.05

Table 2: The overall locations mean performance of the two carrot varieties evaluated during 2019 and 2020 cropping seasons

| Locations | Root Core Diameter (cm) | Root Length (cm) | Root Weight (g) | Marketable Yield (tha$^{-1}$) | Un Marketable Yield (tha$^{-1}$) | Total Yield (tha$^{-1}$) |
|---|---|---|---|---|---|---|
| Wondo Genet | 2.43 | 10.94 | 39.88 | 13.84$^{b}$ | 1.35$^{b}$ | 15.19$^{b}$ |
| Negelle Arsi | 2.57 | 11.46 | 44.74 | 23.11$^{a}$ | 2.013$^{a}$ | 27.19$^{a}$ |
| $LSD_{0.05}$ | ns | ns | ns | 4.48 | 0.47 | 4.03 |

Means followed by the same letter with in the same column are statistically non-significant at P < 0.05

Table 3: Interaction effect of locations and years of carrot varieties evaluated at Wondo Genet and Negelle Arsi during 2019 and 2020 cropping seasons

| Years | Locations | Root Core Diameter (cm) | Marketable Yield (tha$^{-1}$) | Total Root Yield (tha$^{-1}$) |
|---|---|---|---|---|
| 2019 | Wondo Genet | 1.987$^{b}$ | 6.755$^{c}$ | 8.193$^{c}$ |
| 2019 | Negelle Arsi | 2.637$^{a}$ | 29.00$^{a}$ | 31.56$^{a}$ |
| 2020 | Wondo Genet | 2.877$^{a}$ | 20.925$^{b}$ | 22.18$^{b}$ |
| 2020 | Negelle Arsi | 2.493$^{ab}$ | 21.225$^{b}$ | 22.81$^{b}$ |
| $LSD_{0.05}$ | | 0.6067 | 6.04 | 5.679 |
| CV (%) | | 23.58 | 30.117 | 26.027 |

Means followed by the same letter with in the same column are statistically non-significant at P < 0.05

Table 4: Interaction effect of locations and varieties of carrot evaluated at Wondo Genet and Negelle Arsi during 2019 and 2020 cropping seasons

| Varieties | Locations | Root Core Diameter (cm) | Root length (cm) | Unmarketable Yield (tha$^{-1}$) |
|---|---|---|---|---|
| Haramaya-I | Wondo Genet | 2.97$^{a}$ | 13.57$^{a}$ | 1.43$^{b}$ |
| Haramaya-I | Negelle Arsi | 2.74$^{ab}$ | 12.08$^{ab}$ | 2.58$^{a}$ |
| Nantes | Wondo Genet | 1.89$^{c}$ | 8.31$^{c}$ | 1.26$^{b}$ |
| Nantes | Negelle Arsi | 2.38$^{bc}$ | 10.83$^{b}$ | 1.437$^{b}$ |
| $LSD_{0.05}$ | | 0.535 | 2.015 | 0.707 |
| CV (%) | | 20.79 | 17.47 | 40.88 |

Means followed by the same letter with in the same column are statistically non-significant at P < 0.05

rather than storage root development resulting in a reduction in root yield [8]. Not only environment growth and yield can be also affected by year of production. Different growth and yield parameters were responded differently to year of production. Environmental condition in the first year might be different from the second year as a result of climate fluctuation.

The interaction of year and location affected the performance of evaluated carrot varieties. The highest root core diameter was scored in 2020 at Wondo Genet and the lowest was also seen at Wondo Genet in 2019 (Table 3). This might be due to seasonal fluctuations for a short period and changes in soil microclimate of the years. Hence, the highest total root yield (31.56 t $ha^{-1}$) was obtained from Negelle Arsi in 2019 and the lowest was obtained from Wondo Genet in 2019. The variation in root yield might be due to the difference of micro climate in production areas which differ in agro-ecology.

As shown in Table (4), root core diameter, root length and unmarketable per hectare has been affected by varieties and locations (environment) interactions. The longest root core diameter (2.97cm) was observed from Haramaya-I variety at Wondo Genet and the smallest (1.89cm) was recorded from Nantes variety at Wondo Genet. The difference may be because of genotypic effect. Different genotype may respond differently in the same locations. Similarly root length has been affected by the same environment and variety with that of root core diameter. But unmarketable root yield responded differently other than the two parameters. The highest unmarketable root yield (2.58$tha^{-1}$) was observed in Haramaya-I variety at Negelle Arsi and the lowest (1.26$tha^{-1}$) was observed at Wondo Genet for Nantes variety. The interaction occurs due to different sensitivities of genotypes to environmental changes and it is an aggravating factor in plant breeding program [13]. However, for productive characteristics where the effects of the genotype and environment interaction are important, this practice can cause large losses, because these interactions are not defined for each specific environment. This is one reason why it can be difficult to select genotypes for regions that have different soil and climatic features [14].

## CONCLUSIONS

Evaluation of carrot varieties was conducted at Wondo Genet research station and at Negelle Arsi farmers training center (FTC) for two years during 2019 and 2020 on main season. The result obtained during the field experiment showed that presence of variation on growth and yield components differently. Individual factors and their interactions affected the growth, yield and yield components of carrot. When the two varieties (Nantes and Haramaya-I) were compared it was found no significant difference among them; but there was a variation when they were interacted with the year of production. The maximum root yield (31.56 $tha^{-1}$) was obtained in 2019 E.C at Negelle Arsi environmental condition. But there was no significant difference when the two varieties were compared in terms of marketable root yield. But unmarketable root yield was higher for Nantes variety compared of Haramaya-I variety. Producing Nantes variety was better since there was low unmarketable yield than Haramaya-I variety. Negelle Arsi location was the best for production of carrot than Wondo Genet. Year one (2019) was also the best season for carrot production compared to year two (2020). This indicates that the performance of carrot production influenced by different environmental factors, production seasons and inherent character of the genotype. So, consideration of the above factors in carrot production system is crucial.

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