Research Article

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Effect of transplanting on carrot root growth and yield

Abstract

Direct seeding of carrot by broadcasting usually leads to overcrowding of seedlings after emergence. To reduce the undesirable effects of high crop density, uniform seedling distribution is ensured by thinning and discarding of a large number of seedlings. Given the expensive nature of carrot seeds, transplanting of thinned seedlings could be a more useful option than discarding them. It was within this context that this study was carried out at the teaching and research farm of the college of technology of the University of Bamenda, Cameroon to determine the effect of transplanting on root yield of imperator carrot variety**.** The experimental layout was a randomized complete block design (RCBD) with four treatments being T0=direct seeding which served as the absolute Control, and three transplanting days after emergence (DAE) notably T1=Transplanting at 5 DAE, T2=Transplanting 10DAE, T3=Transplanting 15DAE. Variables evaluated were growth in tap root length over time, length of root, fresh weight roots, rate of root forking /plant and root yield (t/ha). Results show that trial under T0 presented significantly higher number of straight roots carrot while all transplanted carrots regardless of the day of transplanting developed 1 to 3 forks at harvest ($p<0.05$). Highly significant differences at $P<0.05$ were noticed at the level of root yield, with direct seeding trial (T0) recording a significantly higher yield of4.25t/ha against1.81, 2.4, and 1.73 t/ha for transplanting at 5 DAE, 10DAE and 15DAE.

Keywords: *Daucuscarota* L., Transplanting, Biometric parameters, Root forking, Root yield

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Introduction

Carrot (*Daucuscarota* L.) is the most important crop of *Apiaceae* family. Among root vegetables, carrot is one of the most popular in terms of economic value because of its short cycle its storage root is rich in carotenoids, anthocyanins, dietary fiber and vitamin A.[1,2] Generally carrot is a cold climate plant and it is mainly propagated by seeds. While wild carrot types are annuals, cultivated varieties are biennial because flowering takes place only in the second year. The appropriate time for flowering is crucial for successful reproduction since in many plant species, the transition of the meristem from vegetative to reproductive development is irreversible.[3] Thus, plants have evolved intricate signaling networks to sense and monitor photoperiod and temperature changes to control flowering time. Prolonged exposure to cold temperatures, which leads to vernalization, is a flower-promoting signal that many plants in temperate regions including carrot use to ensure that flowering occurs under more favorable environmental conditions of the spring. Carrots require a certain number of cold hours to become vernalized and proceed to the reproductive stage.[4] In biennial carrot types, flowering or bolting requires at least 6weeks of vernalization.[5] Even after vernalization, induction, flower stalk elongation (bolting), flowering and seed production are promoted by long day conditions of 16hr.[6] Given that vernalization is a prerequisite to flowering, carrots grown in the tropics hardly flowers. This implies that most of carrots grown in the tropical countries including Cameroon have their seed imported from cold climate countries of Europe and North America.[7] The cost of seeds is very high with 5 g sold at 6 dollars in Cameroon. Carrot seeds are sown mainly by broadcasting method of direct seeding. Since broadcasting hardly ensures homogenous distribution of seeds, thinning is a post emergence agronomic activity carried out in broadcasting field to minimize growth hitches related to overcrowding. Thinning in carrot fields involves the uprooting of some seedlings to reduce crop density as well as intra specific competition which can lead to drop in root yield attributes. All thinned seedlings are often discarded, making the process waste seeds that are usually very expensive. It was within the context of valorizing thinned seedlings of carrot that this study was initiated with the transplanting option prioritized. It was within this backdrop that this study was carried out with the general objective to investigate the influence of transplanting on root yield attributes of carrot.

Materials and methods

Description of study site

The study was carried out at the teaching and research farm of the College of Technology, the University of Bamenda located at between latitudes 5^0 and 6^0N of the equator and longitudes 10^0 East of Greenwich Meridian. The farm is situated 1600 to 2000m above sea level with an average annual rainfall of 2358.7mm and temperature 19.6^{0}C.

Materials and methods

Nursery bed preparation

After clearing the plots were segmented in experimental units of 2m by 2m. Neighboring experimental units were separated by space of 0.5m. Each experimental unit was then ploughed to fine tilt and raised seedbed of 40cm high from the ground level. Well decomposed poultry manure was incorporated into the seedbed during ploughing at a rate of 2.5t/ha at 14days prior to sowing. Breakage of compacted soil layers was done during Secondary tillage to present possible surface capping which can seriously affect emergence and root development of plants. Seedbed surfaces were levelled and lines spaced out by 20cm were pegged from one end of the bed to the other. Drenches of 0.5cm deep were made along the lines prior to sowing. Precaution was taken during seedbed preparation to completely eliminate all stones, sticks and other large size materials.

Sowing

The variety of the carrot sown was imperator distributed by *LE GRENIER, NEW KURODA*. Sowing was done via broadcasting along bands of 0.5cm deep on seedbeds by mixing the seeds with sand to ensure even distribution of the seed. Inter line spacing was 40cm on the drills. After seeding, seedbeds were covered with a thick layer of dry grass mulch to protect the seed from sun and the seedbed sufficiently watered to field capacity. This variety was chosen for its great adaptability to rainy season and short growth cycle (80days).

Trial layout and experimental Design

The experimental design was randomized complete block design with four replicates and four treatments: T0=control; T1=Transplanting 5DAE; T2=Transplanting 10DAE; T3=Transplanting 15DAE. Each replication comprised of three subplots of sizes 2 by 2m. Each elementary plot of T1, T2, T3, comprised of 24 transplanted carrot seedlings.

Transplanting

Prior to uprooting of seedlings, the nursery bed was sufficiently irrigated to minimize damage the root system. Holes of depths 10 cm were made along bands on raised flatbed at interplant distance of the 15cm. and interline distances of 15 cm. Uprooted seedling at the respective days 5, 10 and 15DAE were carefully placed in holds. Transplanting of the seedlings was done in the early hours of morning. Immediately after transplanting, light irrigation was done to hold the roots firm in the soil.

Photo showing root length at 5, 10, 15 and 35DAS.

Crop management processes

Weeds control was done mechanically, by hand, and a hoe at 3weeks interval. Pests and diseases were very insignificant and so no special treatment was administered in effect.

Harvest methods

Carrots were considered ready when the root shoulder emerged from the soil. Harvesting was done at 70th day after seedling emergence. Harvesting was done by handling the leaves and pulling upward. After harvesting, grading was carried out to differentiate carrots with straight roots, from those with fork roots.

Data collection and analysis

Data was collected for growth parameters like increase in vertical growth of root length over time, fresh weight of whole plant at harvest, root forking and fresh weight of roots. Data for the vertical growth of root was collected from 5 plants randomly selected/ experimental unit after taking into account the boundary effect. The data collected was analyzed using GenStat statistical software. The treatments with significant means were compared by least significance difference (LSD) at 95%.

Results and discussions

Planting methods such as direct seeding and transplanting are cultural practices that greatly influence root and shoot growth, yield, and fruit quality in high value vegetable crops.

Effect of transplanting on growth of tap root

In the direct seeding trial, a mean increase in length of 0.92cm/day within the first 10 DAE, at the interval 11 - 20 DAE, mean daily elongation of tap root dropped to 0.67 cm and from day 21 to 30, it decreased to 0.43 cm. From day 31 to 70DAE, daily increase in tap root length stood at 0.1 cm and didn't show any significant difference throughout, indicating the stable growth period in length of tap root (Figure 1). As for the Transplant trials a significant decrease in mean daily vertical growth rate of tap root compared to the control trial at P<0.05. Ten days after transplanting a mean daily increase in tap root growth was 0.3cm and only increased by 0.15 cm 21-30 DAE. The daily growth rate then remained at average of 0.05 cm from day 31 – 70 (Figure 1). Horizontal growth only started 35 DAE meaning within the first 35days, carrot concentrate its resources on vertical growth. In this study, a general increase in vertical growth of tap root was noticed within the first 20 days. The exponential phase of vertical growth of tap root ended within the first 20 days after germination, while stationary growth phase was noticed from 21 DAE with a drastic reduction in mean daily vertical growth of tap root/plant till harvest at 70 DAE. This increase has been attributed to root apical meristem, said to be responsible for vertical growth of tap root. The apical meristem contains stem cells which maintain its pluripotent state throughout the lifespan of the plant.[8] It was also observed that the carrot plant invested its resources on vertical growth of tap root during the first 35 DAE while the rest time of its life was dedicated to horizontal growth. In this study it was noticed that root yield attributes like, normal carrot root morphology, mean length, root weight and yield were better in the control that in transplants. In terms of vertical growth the results show a significantly longer root length in direct seeding than in trials of all transplanting dates at 10, 15 and 35 DAT. Our results do not tie with that of[9] who reported that in the onion plant, transplanting resulted in higher yield than direct seeding, probably because Onion is a bulb while carrot is a root.

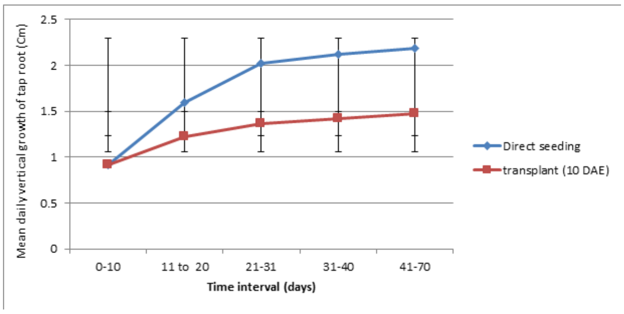

Figure 1 Mean daily vertical growth rate of tap root in direct seeded and transplanted carrot.

Influence of transplanting on FW of plant

The control experiment had the highest mean weight and the weight of each plant was significantly different from the mean fresh weight of the transplants at P<0.05. All transplants did not show significant differences when compared within themselves (Figure 2). The control had the highest mean FW/plant of 203.7g while transplants 15DAE had the least of 124g at harvest which took place 70DAE. Though variations were recorded in FW of the whole plant between the control and the transplants, no significant differences were observed when it came to FW of the root (Table 1).

Influence of transplanting on root length

The results show that at harvesting, the control gave the longest root 23.49cm compared to the transplants. The least length at harvest was 15.62cm noticed in transplants of 5DAE. No significant differences were recorded between the different transplanting days, but significant differences were recorded when the transplants were compared to the control experiment (Table 1).

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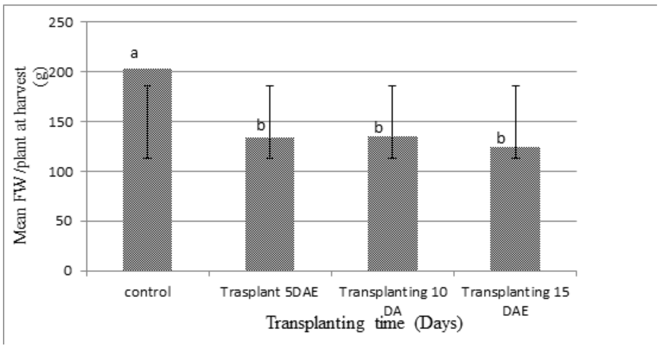

Figure 2 Effect of transplanting on FW of plant at harvest (70 DAE).

* Different letters on histograms show significant differences at P < 0.05.

Table 1 Effect of transplanting on root length of carrot at harvest

Treatment	Mean root length/ plant (cm)	Mean root weight (g.root^{-1})
Control (no transplanting)	23.49^{a} ±2.93	83.5^{a} ±1.01
Transplanting 5 DAE	15.62^{b} ± 2.62	79.9^{a} ±3.45
Transplanting 10 DAE	18.88^{b} ± 0.31	80.2^{a} ±1.91
Transplanting 15 DAE	19.34^{b} ± 0.01	81.2^{a} ±0.41

Effect of transplanting on rate of root forking/plant

The number of roots with forks (Figure 3A) against normal roots (Figure 3B) at harvest was significantly higher in transplants compared to the control regardless of the transplanting date at P <0.05 (Figure 4). However among transplants, root forking varied with the day transplanting was done after emergence. Transplants at 5 DAE comparatively recorded a significantly fewer number of roots with forks against transplants at 10 and 15 DAE (Figure 4).Considering root morphology, it was observed that direct seeded carrot produced significantly lower forks compared to transplants at 5, 10 and 15DAE. This results tie with that of[10] who reported that while direct seeded plants develop a vertical strong taproot in non-compacted soils, transplanted seedlings develop a distinctive root system with typically more basal roots derived from the root–hypocotyl transition zone, which provokes early modification of the taproot. According to,[11] direct-seeded cotton exhibits a typical taproot system, whereas transplanted cotton roots spread outward in the shape of a claw with approximately 2–3dominant lateral roots. The significantly higher root yield traits of direct seeded carrots compared to the transplanted carrot noticed in this study could be associated to the works of[12] who reported that direct seeded plants sustained more balanced root, stem, leaf, and dry matter partitioning than transplants.

Figure 3 Carrot roots at harvest (70DAE).

A. Carrot with Forked roots B. Normal carrot roots

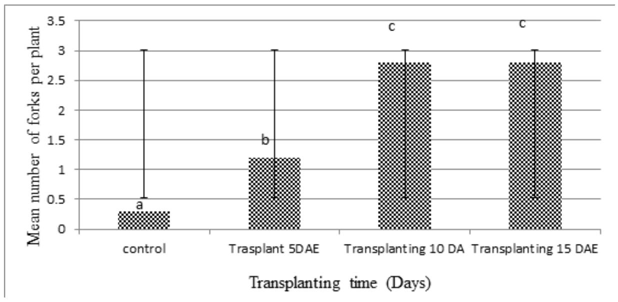

Figure 4 Mean number of forks /plant at harvest.

* Different letters on histograms show significant differences at P < 0.05.

Physiological studies have shown that the development and organization of a root system is determined by the interaction of genetic factors and response to environmental factors.[13] The high level of forked roots obtained in transplanted trials of carrot could be linked to environmental factors given that only one variety was used. One of the factors could be the fact that during transplanting, the apical meristem of taproot bends in any direction, hence provoking cambial meristem to initiate the development of lateral roots. Similar results had been reported by[14] who found that applying bending stress to the taproot of *Fraxinusornus* induces the development of lateral roots at the angle of the curvature. Generally transplanting process has several challenges notably high rate of root hair lost. This damage severely decreases hydro-mineral nutrition in transplants, hence delay in growth.

Influence of transplanting on yield (t/ha)

As concerns root yield, transplants presented significantly lower tonnage (t/ha) compared to the absolute control at P<0.05. Among the transplants, no significant differences were observed among the transplants at 10 and 15DAE (Figure 5). The highest root yield was 4.25t/ha, followed by transplants at 10 DAE with 2.14 t/ha, then 5DAE with 1.81t/ha and the lowest root yield of 1.73t/ha recorded in 15DAE. The low yields recorded in all transplants could be attributed to the fact that, transplanting means a complete change in the growth environment of the roots.[15] Uprooting of seedlings from a direct seeded nursery traumatizes the plant and leads to some interruption of root growth and development once after transplanting. Therefore, the speed and quality of root recovery after transplanting are important factors that might have affected the root water uptake and assimilate partitioning in various sinks in transplanted carrot trials.

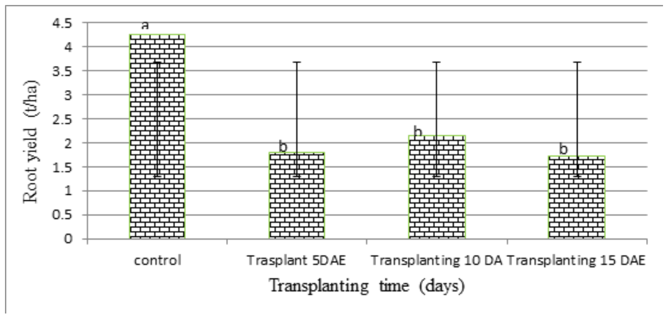

Figure 5 Influence of transplanting on root yield.

* Different letters on histograms show significant differences at P < 0.05.

Conclusion

The purpose of this study was to evaluate the effect of transplanting on root morphology and yield of carrot. Results obtained showed

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that direct seedling i.e. absolute control (T0) recorded normal shaped roots while transplanted carrots registered at least 1 forked root/ plant. Transplanting at 5DAE gave average of 0.6forked roots/plant while transplanting at 10 and 15DAE gave a mean root forking rate of 2-3forks per plant. In addition, carrot plants from control gave the longest root (23.49cm) at harvest and highest root yield (4.24t/ ha). In this study we have shown that when the young carrot taproot is disturbed during uprooting and/or transplanting, the root system respond in two ways. If during uprooting the young taproot is cut, the response is induction of one or more lateral roots from the cut point which further develop at relatively the same rate. On the other hand if the complete taproot is uprooted but in the course of transplanting the end of the young taproot formed a curvature, vertical growth stops and one lateral branch develops at about midpoint of the main taproot. In this regard, the taproot system of transplanted carrots at harvest appears short and split at its rear end into two or three short root branches of relatively same length and circumference. The results of this study therefore suggest that direct seeding by broadcasting is a better option for sowing carrot rather than transplanting of seedlings.

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Conflict of interest

The author declares that there has no conflict of interest to publish this manuscript.

References

1. Que F, Hou X, Wang G, et al. Advances in research on the carrot, an important root vegetable in the Apiaceae family. *Horticulture Research*. 2019;6(69):1–15.
2. SimõesAdon, Moreira SI, da Costa FB, et al. Population density and harvest age of carrots for baby carrot manufacture. *Hortic Bras*. 2010;28(2):147–54.
3. Michaels SD, Amasino RM. Memories of winter vernalization and the competence to flower. *Plant Cell Environ*. 2000;23:1145–1153.
4. Wohlfeiler J, Alessandro MS, Morales A, et al. Vernalization Requirement, but Not Post-Vernalization Day Length, Conditions Flowering in Carrot (Daucuscarota L.). *Plants*. 2022;11:1–10.
5. Alessandro MS, Galmarini CR, Iorizzo M, et al. Molecular mapping of vernalization requirement and fertility restoration genes in carrot. *Theor Appl Genet*. 2013;126:415–423.
6. Atherton JG, Basher EA. The effects of photoperiod on flowering in carrot. *Journal of Horticultural Science*. 1984;59:213-215.
7. Cameroon Ministry of Agriculture and Rural development, Decision No 541/MINADER/SG/DRCQ/SDRSQV of 7th September 2006 spelling list of vegetables seeds imported into Cameroon. 2006.
8. Jiang K, Feldman LJ. Regulation of root apical meristem development. *Annu Rev Cell Dev Biol*.2005;21:485–509.
9. Macias-Leon M,Leskovar D. Containerized onion transplants: A management system to enhance growth, yield, and quality. *Hort Science*. 2019;54:60–69.
10. Leskovar D, Clark J, Sprague R. Yield, quality, and water use efficiency of muskmelon are affected by irrigation and transplanting versus direct seeding. *Hort Science*. 2001;36:286–291.
11. Mao SC, Li PC, Han YC, et al. Preliminary Observation on Morphological Parameters of Root System of the Root-naked Transplanting Cotton (*Gossypiumhirsutum* L.). *Cotton Sci*. 2008;20:76–78.
12. Leskovar D,Cantliffe D. Comparison of plant establishment method, transplant, or direct seeding on growth and yield of bell pepper. *J Am Soc Hort Sci*.1993;118:17–22.
13. Malamy JE, Benfey PN. Down and out in Arabidopsis: the formation of lateral roots. *Trends Plant Sci*. 1997b;2:390–395.
14. Chiatante D, Scippa GS, Iorio A, et al. Lateral root emission in woody taproots of *Fraxinusornus* L. *Plant Biosystems*. 2007;141:204–213.
15. Dong HZ, Li WJ, Tang W, et al. Increased yield and revenue with a seedling transplanting system for hybrid seed production in Bt cotton. *J Agron Crop Sci*. 2005;191:116–124.

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