Effect of Planting Methods on the Growth and Yield of Carrot (*Daucus carota* L) in Humid Tropical Zone

Obidiebube, E. A., Okolie, H., Obasi, C., Ndukwe, O. O., Muojiama, S., Eche, P. and Umeh, O. A.*

Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka. Anambra State, Nigeria

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*CORRESPONDING AUTHOR

ae.ocidiebube@unizik.edu.ng

ABSTRACT

The experiment was conducted at the research farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria; to study the effect of planting methods on the growth and yield of carrot (Daucus carota L). Two planting methods, direct sowing and transplanting were used as treatments for the experiment, which was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. Data was collected on the growth, yield and root marketability. The collected parameters were statistically analyzed by analysis of variance table and means were separated using Least Significance Difference (LSD) at 5 percent level of significance with the GENSTAT 2014 Edition. The results showed no significant variation between the planting methods on the stem girth and leaf number at some dates, while transplanting significantly varied (P<0.05) from direct sowing at 4, 6, 8 and 10 WAP. Planting methods did not affect some parameters (plant biomass, root length, number of roots harvested, fresh weight of leaves, and fresh weight of roots), rather they were statistically similar. Transplanting influenced significantly the root diameter, while the harvest index showed statistical difference between the planting methods, with direct sowing varying significantly. Direct sowing also significantly influenced the root marketability parameters; root uniformity, marketable yield and total marketable root yield percetage. From the results presented, direct sowing had significant effect on root marketability, which is paramount in commercial carrot production. It is thereby recommended that for optimum carrot production and marketability, carrots should be directly sown.

INTRODUCTION

Carrot (*Daucus carota L.*), is a biennial herbaceous specie and a member of the Apiaceae family and known to be one of the most important root vegetables cultivated worldwide (Que, *et al.*, 2019). Carrots are believed to have originated in Europe or the Western Mediterranean, with origins in Persia which are now known as Iran and Afghanistan, where it was originally cultivated for its leaves and seeds (Afrin *et al.*, 2019).. In Nigeria, carrot is largely cultivated in the Northern parts like Zaria, Sokoto, Kano and Jos (Finelib.com, 2013). It has a range of colours like purple, black, red, white, yellow and orange which is the most common and popular colour.. It contains appreciable amount of carotene, thiamin, riboflavin, iron, calcium and phosphorus. Carrot is either consumed fresh (raw) or cooked (Afrin *et al.*, 2019). The root, which is the edible part, is a swollen base of the tap root that includes the hypocotyls. It is conical and its length varies from 5 to 25 cm. The high levels taste and digestibility are among the reasons why carrot is valuable (Kharsan *et al.*, 2019). The flavored sweet taste of carrots referred to sugar contents such as glucose, fructose and starch which are the main types of carbohydrates (Que *et al.*, 2019). Carrot therefore has been used as a potent antioxidant to combat certain types of cancer (Singh *et al.*, 2018). Carrot is used as salad, cooked as vegetables preferably with potatoes, peas and other vegetables; its juice and extracted oils are also becoming quite popular (Patel *et al.*,2019). During root enlargement, carrot is sensitive to moisture stress and water stress causes small, woody and poorly flavored roots, it also causes growth cracks (Afrin *et al.*, 2019).

Carrot is among the profitable vegetable product to promote due to its high nutritional value. However, its productivity is reduced slowly due to poor application of fertilizers, poor agronomic practices, diseases and insect attack (Ige *et al.*, 2017). Apart from

temperature and nutrient composition of the soil, carrots are very sensitive to weeds and plant spacing (El-Sayed, 2021). In Nigeria the increased carrot production has become feasible by the application of sufficient plant nutrients to depleted soils to improve soil fertility (Ige *et al.*, 2017). However other factors like, wasting seeds and seedlings due to the small size of carrot seeds for the former and thinning seedlings to reduce competition for the later, water and weed management still pose a problem in carrot production. In vegetable production, nursery raised seedlings are known to be healthy, strong and have maximum germination rate. Raising vegetables in nurseries is a convenient way to plant small seeds and care for large number of seedlings in small area, while reducing seed and seedlings wastage and making production cost effective (Costa *et al.*, 2020). This study aims to determine if transplanted carrot will have positive characteristics in comparison with directly sown seeds, which can therefore reduce the cost and improve ease in carrot production.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the research farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka. This area has a mean rainfall range above 1100mm and lies between latitude 06º15N, longitude 07º08E, with a minimum and maximum average temperature of 27ºC to 30ºC (Ndukwe *et al*., 2020).

Experimental Materials and Treatment Application

The carrot Seeds used in the experiment was the Carrote Touchon variety which was obtained from a reputable seed dealer in Jos, Plateau State. Two treatments which were replicated 4 times were applied: T1 - transplanted carrot T2 - directly sown carrot.

Field Experiment Description

The experiment was laid out in a complete Randomized Complete Block Design (RCBD) replicated four times and conducted in a field with a total area of 17m x 23m. The field layout was designed using randomization to allocate each treatment and their replications to specific plots (beds) without bias. The chosen site of 17m x 23m was cleared of its existing vegetation, manually with cutlass, before beds of 1m by 2m and furrow spacing of 0.5m were raised with hoes. The beds were then incorporated with poultry manure at equal rates to aid the growth of the carrot. Part of the chosen site was also tilled and incorporated with poultry manure as the nursery.

Sowing of Seeds

For treatment 1, directly sown treatment, the carrot seeds were sown at the rate of 4 per hole at 2cm depth and with the plant spacing of 30cm by 50cm. While the seeds for the transplanting was evenly broadcasted in the nursery. The carrot seedlings in the nursery were transplanted three weeks after germination into raised beds of 1m by 2m, the seedlings were spaced 30cm × 50cm. The directly sown seedlings were thinned down to one seedling per stand.

Data Collection and Analysis

Data for the growth parameters (plant height (cm), number of leaves per plant, stem girth per plant (cm),were collected at the interval of two weeks after planting. While the yield parameters(diameter of root per plant (cm), total yield of roots per bed (tones/ha), plant biomass (g), harvest index on fresh weight basis (%), number of harvested root per bed, root length (cm), root marketability (those ones that were smooth, sizable and neat at sight without deformity), marketable yield (tones /ha),total marketable root yield (%), root uniformity (%))were collected immediately after harvest. The collected parameters were statistically analyzed by analysis of variance table and means were separated using Least Significance Difference (LSD) at 5 percent level of significance with the GENSTAT 2014 Edition.

Tuber uniformity (%)

Data was collected on root uniformity by visual examination of the roots using a uniformity index score created as shown Table 1.

Table 1.Root uniformityindex score

Index		Description
1	Not Uniform	<30% of the roots are similar in size and shape
2	Fairly Uniform	>30%<50% of the roots are similar in size and shape
3	Uniform	>50%< 70% of the roots are similar in size and shape
4	Very Uniform	>70%<90% of the roots are similar in size and shape
5	Highly Uniform	>90% of the roots are similar in size and shape

Source: Obidiebube *et al.,* (2022)

RESULTS

Physico chemical properties of the soil samples utilized in the study

The result of analysis carried out with soil samples collected from the experimental site as presented in Table 2., shows the physical and chemical soil properties. Based on the physical soil properties, there was high percentage of sand (71.2%), clay was the least (8.4 %) while the textural class of the soil is sandy-loam. The chemical soil properties showed the percentage base saturation to be 80.23 %, organic matter 1.98%, and Total N0.97%, other parameters were also determined.

Table 2: Physical and Chemical properties of the soil samples taken at 0 – 15cm depth of the experimental site before planting.

Soil Properties	Value
Physical	
Sand (%)	69.6
Silt (%)	22.0
Clay (%)	8.4
Textural Class	Sandy-Loam (SL)
Chemical	
pH (H20)	5.14
Total N%	0.97
Organic Carbon%	1.14
Organic Matter%	1.98
Ca (Cmolkg-1)	2.27
Mg (Cmolkg-1)	1.33
K (Cmolkg-1)	0.25
Na (Cmolkg-1)	0.12
EA (Cmolkg-1)	1.63
ECEC (Cmolkg-1)	4.97
BS (%)	80.23
Available P (mgkg-1)	5 53

Source: Department of Soil Science and Land Resources Management Soil Laboratory, NAU, Awka

Effect of Planting Methods on the Vegetative Growth (Plant Height, Number of Leaf and Stem Girth) of Carrot (Cm):

In Table 3, it was observed that plant height of the transplants progressively increased across the sampling periods; and were mostly higher than the directly sown seedlings. At 4 and 12 WAP Treatment 1 (transplants) had the highest mean values of 19.8 and 59.2 respectively, while Treatment 2 (directly sown) had the mean value of 15.21 and 43.8 at 4 and 12 WAP respectively. With this result in Table2 I 4 and 12 WAP, transplants were significantly different ($P<0.05$) from directly sown plants. In the same Table 2, both methods were significantly similar ($P<0.05$) at 6, 8 and 10 WAP (Weeks After Planting).

On leaf number, Table 3 showed that the planting methods had no significant effect ($P<0.05$) on the leaf number of the carrots. The highest mean values were observed from 12 WAP with transplants having mean value of 23.2, while directly sown plants had 18.8 and was not significantly different ($P<0.05$).

Finally, with the highest mean values of the stem girth as 15.31cm (T1) and 12.10cm (T2) at 12 WAP and least mean value of 3.42cm (T2) at 4WAP, planting methods did not significantly ($P<0.05$) influence the size of the stem girth throughout the sampling periods as indicated in Table 3.

Table 3: Effect of planting methods on the plant height, number of leaves and stem girth of carrot.

		Plant Height			
Treatment	4WAP	6WAP	8WAP	10WAP	12WAP
1	19.84	35.1	49.4	51.9	59.2
2	15.21	28.2	38.8	48.0	43.8
LSD 5%	3.614*	5.18 ns	5.93 ns	6.03 ns	5.31*
		Leaf Number			
T1	4.17	6.33	10.75	16.4	23.2
T2	3.42	6.08	10.50	14.1	18.8
LSD 5%	1.448 ns	1.614 ns	3.503 ns	5.49 ns	11.28 ns
		Stem Girth			
T1	1.91	4.33	8.51	13.23	15.31
T2	2.13	4.02	7.48	11.43	12.10
LSD 5%	0.75 ns	1.33 ns	2.721 ns	3.77 ns	4.26 ns

T1 - Transplanted Carrot, T2 - Directly Sown Carrot

Response of some carrot yield parameters to planting methods

On biomass shown in Table 4, no significant difference (P<0.05) was observed between the plant biomass of the transplanted and directly sown carrot.

For fresh weight of leaves in Table 4, it indicates that the planting methods had no statistical influence on the fresh leaf weight of the transplanted and directly sown carrots, showing that the transplants and the directly sown plants were significantly similar (P<0.05). The highest mean value was produced by T1 (330) followed by T2 (213).

On fresh weight of roots as was recorded Table 3, the fresh weight of the harvested roots did not significantly vary (P<0.05) and were not influenced by the effect of the planting methods, Transplanting and Direct Sowing. The highest average root weight recorded was that of T (145) and the lowest was T2 (120).

Finally, on harvest index% planting methods influenced the harvest index of carrot. As portrayed in Table 3, the harvest index of the transplanted and directly sown carrot differed significantly (P<0.05), with the directly sown plants statistically influenced the harvest index. The highest index recorded was obtained from T2 (56.8%) and lowest T1 (43.3%).

Table 4. Effect of planting methods on plant biomass, fresh weight of roots, fresh weight of leaves and harvest index% of carrot.

Treatment	**Plant Biomass**	**Fresh Weight of Roots ns**	**Fresh Weight of Leaves ns**	**Harvest Index %**
T1	330	145	186	43.3
T2	213	120	95	56.8*
LSD 5%	153.9	70.7	105.2	10.25

Response of number of roots, rootlength and diameter per plot to the planting methods

Statistically there was no significant difference (P<0.05) between the number of roots harvested per plot of the transplanted and directly sown carrot, indicating that the planting methods applied as treatments did not influence the number of carrot root produced as revealed by Table 4. The highest producing plot/bed during the course of this study was T1 (6.25), whilst T2, produced 5. 75 roots which was the lower than that of T1.

Result in Table 5 showed that root length of the transplanted and directly sown carrots did not show any significant (P<0.05) variance. Hence planting methods did not have significant effect on the length of roots produced. The lowest root length mean observed was that of T1 (17.2 cm) while TR2 (20.4 cm) gave the highest mean value.

On root diameter recorded in Table 5, it showed that planting methods influenced the root diameter of the transplanted and directly sown carrots. The transplants were significantly different (P<0.05) from the directly sown carrots and affected the diameter of the roots produced. The T1 had 5.58 while T2 had mean value of 3.93.

Table 5. Effect of planting methods on number of roots harvested per plot, root length and root diameter of carrot

Treatment	No HR/plot ns	Root Length	Root Diameter
T1	6.25	17.2	5.58*
T2	5.75	20.4	3.93
LSD 5%	3.837	9.41ins	0.842

Results on the Marketability of Carrot Roots

Effect of planting methods on the root uniformity, marketable yield and percentage

The roots of the harvested carrots as illustrated in Table 6, varied significantly (P<0.05) with the directly sown carrots having higher uniformity than the transplanted carrots showing that planting methods had significant influence on the shape and size of the harvested carrots. The directly sown plants resulted in highly uniform roots per plot with the highest value being 4.25 while transplants had 2.00.

On marketable yield, result in Table 6 showed that planting methods influenced the root marketable yield, with the directly sown carrots varying significantly (P<0.05) with higher values than that of the transplants. The directly sown plants had highest marketable value 5.75 out of 7 harvested, while transplants had 2.5 out of 7 too.

Finally, on yield % in Table 6, resultportrayed a significant difference (P<0.05) between the transplanted and directly sown carrots. Planting methods therefore influenced statically the marketability% of carrots. The marketability Yield% of the directly sown plants was significantly (P<0.05) higher than that of the transplants.

Table 6. Effect of planting methods on the root uniformity, marketable yield and marketable yield% of carrots

Treatment	Root Uniformity	Marketable Yield	Marketable Yield%
T1	2.00	2.5	26.0
T2	4.25*	5.75*	100.00*
LSD 5%	1.539	1.966	23.86

DISCUSSION

The results of the growth parameters on transplanted and directly sown carrots observed in this experiment followed a significantly similar trend in almost all the growth prameters across the weeks after planting WAP. This is in line with Leskovar and Othman, (2021) who reported on globe artichoke, that direct seeding and transplanting were statistically similar in both periods of experimenting. The findings here also agrees with the work of Adesina *et al* (2014), who observed similar heights between the direct seeded and other seedlings transplanted at 19 and 14 DAP in maize, as regards plant height.

Meanwhile, the statistical significance between the plant height of the planting methods at 4 and 12 WAP can be attributed to climatic conditions and more importantly a reduction in the mean values of the directly sown plants after 10 WAP as opposed to the continuous improvement in the plant height of the transplants. This finding agrees with Afrin *et al*., (2019), work on directly sown carrots, which indicated that, plant height was an important growth contributing character during the experiment, in which the growth rate of the plants at earlier stage were higher, then became slower at the later stage of development, as noticed with the directly sown carrots. The transplanted, did not follow this trend, instead it grew progressively which resulted in the significant difference observed. This resonates with Leskovar and Othman's (2021) report that more uniform growth is higher in transplants compared to direct seeding. The root diameter was significantly influenced by planting methods, with the transplanted seedlings having higher value when compared to the directly sown seeds, which is in agreement with the reports of Khozaei *et al* (2020), when commented that transplanting significantly influenced the yield, water productivity and quality of sugar beet. The significant similarity between planting methods in the root length corresponds to the findings of Mbatha *et al* (2014), who observed that carrot root length was not significantly influenced by any of the treatments applied. It also concedes with Leskovar and Othman's (2021) report that length values for direct seeded plants never exceeded those of transplants across months and over the study period in globe artichoke. The observed non significance difference on the fresh root weight (FTW) and number of harvested roots per plot (NHP) are in tune with Nikmatullah *et al* (2021) and El-Sayed (2021) who respectively stated that there was no significant difference observed from the planting methods applied on carrot and that, there were no differences between the two planting methods concerning the yield and root weight of carrot. On number of harvested plant, Adesina *et al* (2014) reported that fruit yield in maize was not significantly influenced by planting methods (transplanting and direct seeding), instead it was influenced by planting density.

The Harvest Index resulted in significant variance between transplants and the directly sown plants where directly sown plants had significant higher values. This corresponds with Kakar *et al*., (2015) report which revealed that planting methods had significantly affected the harvest index of wheat. The Marketability Parameters followed the same trend; root uniformity, marketable yield and

marketable yield percent (%) all differed significantly, with the direct sown carrots significantly influencing all marketable parameters. According to Leskovar and Othman (2021), planting methods affect marketable yields, root and shoot biomass allometric partitioning and early root development amongst others. This is similar to carrots, as the planting methods (transplanting and direct sowing) influenced the marketable quality of the roots. Significant difference between planting methods in root uniformity can be attributed to the dissimilarity in size and shape of the harvested carrot roots. The forked, irregular and ill-shapen roots harvested from the transplants which is as a result of transplanting, greatly reduced uniformity. This is because most roots harvested from the transplants were of irregular shapes and sizes when compared to the direct seeded roots. According to Fritz, (2012) transplanting of long-rooted vegetables leads to forked roots. This finding is consonant with the study of Wu *et al* (2020), who reported that direct seeding in carrot production is more suitable and transplanting would lead to the occurrence of fork root and loss of commercial value. It was observed that later most nursery raised seedlings resulted in forked roots. Costa *et al* (2020) on another crop reported that direct sowing presented the highest numbers of total and commercial ears per hectare and that transplanting in general, caused loss of commercial fruit quality in baby corn production. Direct sowing significantly increased the Harvest Index and root marketability, which is very important in Carrot production.

CONCLUSION AND RECOMMENDATION

In consideration of the aforementioned results, planting methods did not significantly influence the growth and yield of carrot in the course of this study. Instead direct sowing had significant effect on root marketability which consists of root uniformity, marketable yield and marketable yield%.

Finally, though planting methods used here did not influence both growth and some yield parameters, but then directly sown method carrots is better because the roots are normal in size and shape, therefore should be used for carrot production, until further experiments on other planting methods are completed. It is therefore recommended that carrot seeds should be sown directly for optimum carrot production

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