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Effect of Root Size, Plant Spacing and Umbel Order on the Quality of Carrot Seed

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ABSTRACT

Seed germination was significantly affected by the root size used for preparing the stecklings. Seed produced from very large sized roots resulted in higher germination percentage than that from large sized roots. While, 1000 seed weight, seed moisture content, plant height, root length and fresh and dry weights of seedlings harvested 10 days after germination were not influenced by the root size. Plant spacing had significant effect on 1000 seed weight, root length and fresh weight of seedlings. Wider spacing (45 cm) proved better as compared with close spacings. However, seed moisture content, seed germination, plant height and dry weight of seedlings after 10 days of germination had no significant response to the plant spacings. The umbel position had significant effect on all the parameters used to evaluate the seed quality. Primary umbels resulted in better quality seed followed by the secondary umbels, while tertiary umbels gave poor quality seed. Maximum 1000 seed weight was recorded for primary umbels harvested from plants spaced at a distance of 45 cm.

Key Words: Carrot; *Daucus carota;* Planting distance; Seed production; Seed quality; Umbel position

INTRODUCTION

Carrot (*Daucus carota* var. sativus) is a very common vegetable grown throughout the world. In Pakistan, it is grown on an area of about 11,000 hectares annually with a total production of 1,92,000 metric tonnes carrot roots (Anonymous, 1999). One of the major problems faced by the carrot growers in Pakistan is the availability of good quality seed. Pakistan is enjoying all seasons and is an ideal region for producing vegetable seeds. There are two methods of producing carrot seed in the world, i.e. seed to seed and root to seed method. In Pakistan, root to seed method is mostly used for commercial seed production in carrot as the technique allows selecting true to type and healthy roots for replanting of stecklings. Besides various agronomic practices, quality of the seed produced is affected by the size of roots used to prepare stecklings and planting distance followed. Umbel position and its size also influence the seed quality. Oliva *et al.* (1988) found that the relationship between harvest index and plant density in carrot seed production is very useful in optimising plant population for maximum seed yield and quality. Noland *et al*. (1988) concluded that greater the plant density, greater would be the carrot seed yield but seed quality will be poor. Saharan *et al*. (1993) reported that large and medium sized stecklings prepared from 110 to 125 days old roots, planted at 45 x 30 cm spacing and pinching of second order umbels at their emergence produced the high quality seed in term of seed weight, germination and seed vigour of main and first order umbel seed. Satyaveer *et al*. (1994) found that high density planting in paired rows affected seed weight and vigour adversely in comparison with low density planting. The quality of seed of main and first order umbels was better than that of second order umbels. Szafirowska (1994) recorded significantly higher seed germination and 1000 seed weight for seed from primary umbels than that from secondary umbels. According to El-Adgham *et al*. (1995), seed yield/plant is significantly positively correlated with the number of second order umbels and with the total number of umbels/plant but the plant height is negatively correlated with seed yield parameters. It is thought that large sized roots produce better quality seed. It is a common practice in Pakistan that the farmers are using large and extra large sized roots for preparing the stecklings but no research has been conducted in this regard. The present research work was, therefore, envisaged to find out the effect of mother root size and plant spacing on the quality of carrot seed of different umbel orders.

MATERIALS AND METHODS

The present studies were carried out at the Experimental Vegetable Area, Department of Horticulture, University of Agriculture, Faisalabad, during the year 1997-99. Seeds of carrot cultivar T-29 were obtained from Ayub Agricultural Research Institute, Faisalabad and sown in the field. After 14 weeks, roots were harvested and their different sizes were selected to prepare stecklings. The root sizes were categorised as very large (over 200 g in weight) and large (125 to 150 g in weight). The stecklings were prepared by cutting 1/3 lower portion of the root and also keeping about 5 cm leaf basis. The stecklings were replanted in flat beds on 20-01-1998. The plant to plant distance kept was 15, 22.5, 30 or 45 cm while row to row distance was maintained as 30 cm. The first irrigation was applied just after sowing of stecklings. The subsequent irrigations were given at an interval of 7 – 15 days keeping in view the weather conditions. The crop was kept free of

weeds by eradicating manually and sprayed once with Methyl parathion to protect from insect-pests like cutworms and thrips during the entire growth period.

The experiment was laid out as factorial with randomised complete block design, randomising the root size and plant spacing combinations in the plots, and replicated three times. The net plot size was 1.5 m x 1.8 m. Seed was harvested from each plot from different umbel orders i.e. primary, secondary and tertiary. Following parameters were studied in the laboratory to test the quality of produced seed.

1. 1000 seed weight (g): 1000 seeds were counted from primary, secondary and tertiary umbels in each treatment and their weights were recorded.

2. Seed moisture content (%): Moisture content of seeds from primary, secondary and tertiary umbels of each treatment was recorded using oven dry method, keeping the seeds at 103±2°C for 18 h, and was expressed in percentages (International Seed Testing Association; ISTA, 1985).

3. Seed germination (%): Seed germination of primary, secondary and tertiary umbel seeds of each treatment was counted and their percentages were recorded.

4. Plant height (cm): Plant heights of 10 plants, after 10 days of germination of primary, secondary and tertiary umbels seeds were measured in each treatment with a measuring tap and then their averages were calculated.

5. Root length (cm): Length of root after 10 days of germination of primary, secondary and tertiary umbels seeds, of ten plants in each treatment was measured with a measuring tape and their averages were calculated.

6. Fresh weight of seedlings (g): Weights of ten freshly harvested seedlings of primary, secondary and tertiary umbels seeds in each treatment were recorded and their averages were calculated.

7. Dry weight of seedlings (g): Ten seedlings of primary, secondary and tertiary umbels seeds in each treatment were oven dried at 70°C for 24 h, their weights were recorded and averages were calculated.

The data collected were analysed statistically by constructing the analysis of variance tables. The treatment means were compared by applying Duncan's Multiple Range Test at 5% level of probability (Petersen, 1994).

RESULTS AND DISCUSSION

1. 1000 seed weight (g): Data concerning 1000 seed weight were subjected to statistical analysis and the results obtained depicted significant differences for the plant spacings and umbel orders as well as for interaction between root sizes and spacings, spacings and umbel orders and interaction among all the three factors. Whereas, no level of significant difference was found between the root sizes and for interaction between root sizes and umbel orders.

It was found that the plants spaced 45 cm apart produced maximum 1000 seed weight and differed significantly from other spacings but it stood at par with close spacing (15 cm). The 1000 seed weight produced by 22.5 cm was the minimum and by 30 cm spacing remained in the middle (Table I).

Table I. Effect of plant spacing on the quality of seed produced in carrot

Parameters studied	Plant to plant distance			
	15 cm	22.5 cm	30 cm	45 cm
1000 seed weight (g)	2.938 a*	2.702 c	2.884 b	2.951 a
Seed moisture content (%)	4.11 a	4.11 a	4.13 a	4.12 a
Seed germination (%)	69.33 a	65.57 a	67.54 a	70.67 a
Plant height (cm)	4.11 a	3.95 a	3.92 a	4.15 a
Root length (cm)	4.83 ab	4.57 b	5.03 a	5.06 a
Fresh weight of seedlings (g)	1.525 a	1.420 b	1.515 ab	1.584 a
Dry weight of seedlings (g)	0.377 a	0.327 a	0.373 a	0.393 a

*Any two means in a row not sharing a letter differ significantly at 5% level of probability (DMR test).

As far as the umbel orders are concerned, primary umbels produced more 1000 seed weight as compared to secondary and tertiary umbels. The secondary umbels stood at second position and tertiary umbels produced the minimum seed weight (Table II). These results are in agreement with the findings of Szafirowska (1994).

Table II. Effect of umbel order on the quality of seed produced in carrot

Parameters studied	Umbel order		
	Primary	Secondary	Tertiary
1000 seed weight (g)	3.532 a*	2.789 b	2.285 c
Seed moisture content (%)	4.25 a	4.18 b	3.92 c
Seed germination (%)	88.29 a	75.71 b	40.83 c
Plant height (cm)	4.73 a	4.26 b	3.11 c
Root length (cm)	5.57 a	5.06 b	3.98 c
Fresh weight of seedlings (g)	1.846 a	1.476 b	1.210 c
Dry weight of seedlings (g)	0.453 a	0.360 b	0.290 c

*Any two means in a row not sharing a letter differ significantly at 5% level of probability (DMR test).

Individual comparison of root sizes and plant spacings means (interaction) shows that more 1000 seed weight was produced in case of large sized roots with 15 cm plant spacing, while very large sized roots with 30 cm plant spacing got second position. The other combination like very large sized roots and large sized roots with plant spacing of 45 cm did not differ significantly. The remaining combinations are statistically alike and got lower positions (Table III). The results of the present study are in conformity with the findings of Saharan *et al*. (1993).

Individual comparison of plant spacings and umbel orders means (interaction) for 1000 seed weight differed significantly with each other. Primary umbels with plant spacing of 45 cm produced maximum weight of 1000 seeds and secured the top position. Primary umbels with 30 cm spacing stood at second position. The third position was

secured by primary umbels with 15 cm plant spacing. The tertiary umbels with 45 cm spacing had minimum 1000 seed weight, while the remaining combinations were in between the maximum and minimum (Table IV).

Table III. Effect of root size and plant spacing (interaction) on 1000 seed weight in carrot

Plant to plant distance	Root size	
	Very large	Large
15 cm	2.702 de*	3.174 a
22.5 cm	2.747 d	2.657 e
30 cm	3.081 b	2.687 de
45 cm	2.959 c	2.943 c

*Any two means not sharing a letter differ significantly at 5% level of probability (DMR test).

Table IV. Effect of plant spacing and umbel order (interaction) on 1000 seed weight in carrot

Plant to plant distance	Umbel order		
	Primary	Secondary	Tertiary
15 cm	3.395 c*	2.951 e	2.468 g
22.5 cm	3.242 d	2.612 f	2.253 i
30 cm	3.547 b	2.724 f	2.380 h
45 cm	3.994 a	2.870 e	2.038 j

*Any two means not sharing a letter differ significantly at 5% level of probability (DMR test).

Individual comparison of the interaction among all the three factors shows that 1000 seed weight of different umbel orders significantly differ with each other in regards to plant spacings and root sizes. However, primary umbels of very large sized roots spaced 45 cm apart produced maximum seed weight and stood at par with large sized roots at the same plant spacing. The primary umbels in wider spacing significantly differed to the secondary and tertiary umbels in close spacings (Table V). It is concluded that pant spacing and umbel order play an important role in the production of heavy seed weight.

2. Seed moisture content (%): Data procured on the seed moisture content were subjected to statistical analysis and the results exhibited significant differences for the different umbel orders, while no level of significant difference was observed for the root sizes, plant spacings and the interaction between all the three factors studied.

Individual comparison of means of different umbel orders shows that the seed from primary umbels had the maximum moisture content, while that from tertiary umbels had the minimum. Secondary umbels though fell in between these two, but there was small difference between primary and secondary umbels as compared to tertiary umbels (Table II).

3. Seed germination (%): Data in this regard were processed for statistical analysis and the results were found to be significant only for the root sizes and the umbel orders.

Individual comparison of root sizes indicates that seed produced from very large sized roots gave better germination than that from large sized roots (Table VI), which could be due to greater reserve food material in large sized roots ultimately affecting the seed germination.

Table VI. Effect of root size on the quality of seed produced in carrot

Parameters studied	Root size	
	Very large	Large
1000 seed weight (g)	2.872 a*	2.865 a
Seed moisture content (%)	4.12 a	4.11 a
Seed germination (%)	69.67 a	66.89 b
Plant height (cm)	4.13 a	3.93 a
Root length (cm)	4.89 a	4.85 a
Fresh weight of seedlings (g)	1.550 a	1.472 a
Dry weight of seedlings (g)	0.377 a	0.350 a

*Any two means in a row not sharing a letter differ significantly at 5% level of probability (DMR test).

A review of the three umbel orders indicates that seed from primary umbels gave maximum germination, while that from tertiary umbels resulted in minimum germination and that from secondary umbels was in between (Table II). Similar results have been reported by previous workers (Castro & Andrews, 1971; Satyaveer *et al*., 1994; Szafirowska, 1994).

4. Plant height (cm): Data procured on plant height, after 10 days of germination, were subjected to statistical analysis and the results indicated significant differences for the different umbel orders while no level of significant difference was observed for the root sizes and plant spacings and interaction between the factors studied.

Table V. Effect of root size, plant spacing and umbel order (interaction) on 1000 seed weight in carrot

Planting distance	Very large sized roots			Large sized roots		
	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
15 cm	3.114 e*	2.659 ghi	2.333 m	3.675 b	3.244 d	2.603 hij
22.5 cm	3.382 c	2.714 gh	2.147 n	3.102 ef	2.510 jk	2.360 lm
30 cm	3.709 b	2.987 f	2.547 ijk	3.385 c	2.461 kl	2.214 n
45 cm	3.980 a	2.990 f	1.907 o	3.908 a	2.750 g	2.170 n

*Any two means not sharing a letter differ significantly at 5% level of probability (DMR test).

Umbel orders differed significantly with each other for the plant height. Seed from primary umbels resulted in maximum plant height, while that from tertiary umbels in minimum and that from secondary umbels in between these two umbel orders (Table II). This may be attributed to more seed weight of primary umbels as compared with other umbel orders.

5. Root length (cm): Data concerning this factor of study were subjected to statistically analysis and the results depicted significant differences among the plant spacings and different umbel orders, while the root sizes and interaction between the root sizes and plant spacings fell below the level of significance.

Significantly more root length was recorded in the seedlings raised from the seed produced from wider spacings (45 and 30 cm) as compared to close spacings (Table I). This could be due to more nutrient availability in wider spacings, producing better quality seed resulting in more root length. The results of the present study are in agreement with previous findings (Noland *et al*., 1988).

A further review of the three umbel orders indicates that primary umbel order seed gave maximum root length, while the seed from tertiary umbels resulted in minimum and that from secondary umbels in between these two (Table II). These results are in accordance with the findings of Satyaveer *et al*. (1994).

6. Fresh weight of seedling (g): Data concerning this parameter were subjected to statistical analysis and results showed significant differences for the different umbel orders and plant spacings, while no level of significant difference was observed for the root sizes and the interaction among all these factors.

All the plant spacings did not differ much for fresh weight of seedling except 22.5 cm, which occupied the lowest position but also stood at par with 30 cm spacing (Table I). More fresh weight of seedlings in 45, 15 and 30 cm spacings was related to more root length of seedlings in these spacings. Further, as more 1000 weight was recorded in 45 and 15 cm plant spacings, which resulted in better growth and more fresh weight of seedlings. Tamet *et al.* (1996) have already observed that the growth after emergence was influenced by seed weight; however, relative growth rate was not affected.

All the three umbel orders differed significantly with each other for the fresh weight of seedlings. The seedlings from the seed of primary umbels resulted in maximum fresh weight followed by those from the seed of secondary umbels, whereas those from the seed of tertiary umbels were at the bottom (Table II). This may be due to more plant height and root length of seedlings raised from the seed of primary umbels, ultimately resulting in more fresh weight of seedlings.

7. Dry weight of seedlings (g): Data obtained for dry weight of seedling were subjected to statistical analysis and the results revealed significant differences between the umbel orders, whereas no level of significant difference was found between the root sizes, plant spacings and interaction between these factors of study.

Individual comparison of umbel orders shows that seedlings from the seed of primary umbels had more dry weight as compare to those from the seed of secondary and tertiary umbels. The seedlings produced from the seed of tertiary umbels had minimum dry weight, while those from the seed of secondary umbels were in the middle (Table II). As the seedlings from primary umbels seed had significantly more fresh weight, therefore, their dry weight was also more as compared with the seedlings from other umbel orders seed.

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