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IMPACT OF MOTHER ROOT SIZE AND UMBEL ORDER ON THE YIELD AND QUALITY OF SEED PRODUCED AND RESULTING ROOTS IN CARROT

ABSTRACT

Yield and quality of carrot seed were not affected by the mother root size used. However, the umbel position had significant influence on all the parameters used to evaluate the seed yield and quality except seed water content, which gave no significant response to the umbel order. Primary umbels resulted in better seed quality followed by the secondary umbels and whole plant, while tertiary umbels gave poor quality seed. All the seed yield and quality parameters studied also differed significantly for the interaction between mother root size and umbel order. Growth and yield of resulting roots were also not affected by the mother root size but were significantly influenced by the umbel order and its interaction with root size, indicating the supremacy of primary and secondary umbels on whole plant and tertiary umbels.

Key words: *Daucus carota*, root yield and quality, seed production, stecklings, umbel position.

INTRODUCTION

Role of seed quality in crop production is well documented. The carrot seed yield and quality is influenced by mother root size, health of mother plant and cultural practices followed. However, seed vigour and germination may be impaired during storage. Re-planting of full root results in higher seed yield, large primary umbels and more number of secondary umbels per plant (Ahmad and Tanki 1997). Stecklings from large sized roots produce higher seed yields (Verma *et al.* 1993). In an experiment, 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 vigour of main and first order umbel seed (Saharan *et al.* 1993).

In carrot, seed yield is significantly positively correlated with the number of second order umbels and with the total number of umbels per plant (El-Adgham *et al.* 1995). Umbel position and its size also influence the seed quality. The quality of seed of main and first order umbels is better than that of second order umbels (Gill

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et al. 1981, Satyaveer *et al.* 1994). Seed quality from primary, secondary and tertiary umbels may deteriorate in descending order (Amjad and Anjum 2001). The seed from primary umbels results in significantly higher seed germination and 1000 seed weight than that from secondary umbels (Szafirowska 1994). Seed size influences the emergence and early growth of carrot seedlings under different seed bed and sowing conditions (Tamet *et al.* 1996). Large sized seed results in increased individual root weight and total and marketable root yield (Sokolowska *et al.* 1995). It is a common practice in Pakistan that the farmers are using large and extra large sized roots for preparing the stecklings with the assumption that the large sized roots produce better quality seed but no comprehensive research has been conducted in this regard. Further, if the seed of good quality is used to raise the crop, it will reduce seed rate, give a uniform crop, increase the yield and improve the quality of carrot roots and finally reduce the cost of production per unit area and increase grower's profitability. The present research work was, therefore, envisaged to observe the yield and quality of carrot seed harvested from different umbel orders resulting from varying mother root sizes and its ultimate effect on yield of the roots produced.

MATERIALS AND METHODS

Studies were carried out during the years 1997-99. Certified seed of carrot cultivar T-29 was obtained from the Ayub Agricultural Research Institute, Faisalabad. The seeds were sown on 7th October 1997 in the field on both sides of raised beds prepared 75 cm apart. First irrigation was applied just after sowing the seeds. Subsequent irrigations were applied depending upon the requirement of the crop. After two weeks of sowing, the crop was thinned out to maintain the plant to plant distance of 5 cm. The crop was fertilized @ 60 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1}. The crop was also hoed manually and kept free from weeds during the entire growth period. After 15 weeks, the crop was harvested and roots of large sized (125 to 150 g in weight) and very large sized (over 200 g in weight) were selected to prepare the stecklings. 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 at 60 x 30 cm spacing in flat beds on 20th January 1998. The net plot size was 1.5 x 1.8 m. The seeds were harvested separately from primary, secondary and tertiary umbel orders and also from whole plants during May 1998 and data on 1000 seed weight (g), seed yield per plant (g) and seed water content (%) were recorded. Water content of seeds of each treatment was estimated using oven dry method, placing 2 g seed samples at 103 ± 2 ºC for 18 h, and expressed in percentage (ISTA, 1985). Seed lots were stored under laboratory conditions and tested before sowing for their germination at 24 ºC and 12 h photoperiod in a growth chamber. Seeds were sown in the field on 3rd October 1998 for further studies. Cultural practices were same as for the mother crop sown on 7th October 1997. After 120 days of sowing (on 31st January 1999), the crop was harvested and ten plants were randomly selected to record the data on the following root characteristics; average root length (cm), diameter (cm) and weight (g), and root yield (t/ha).

Statistical design and analysis: The experiments were laid out as factorials with randomised complete block design under field conditions and completely randomised design for laboratory conditions. In all, there were eight treatments (two mother root sizes x four umbel orders) and four replications. The data were analysed by constructing the analysis of variance tables. The treatments means were subjected to Duncan's multiple range test at 5% probability level for their comparison (Petersen 1994).

RESULTS AND DISCUSSION

Seed characteristics

Weight of 1000 seeds was not significantly affected by the mother root size. However, umbel order had a significant effect on the weight of seeds. Maximum 1000 seed weight was recorded in the seeds produced from primary umbels and the minimum in those produced from tertiary umbels (Table 1). Similar results were reported by previous researchers (Krarup and Duran 1982, Malik *et al.* 1983, Szafirowska 1994). In case of combined effect of mother root size and umbel order (interaction), maximum 1000 seed weight was produced by primary umbels from large sized roots and the minimum by tertiary umbels of both root sizes (Table 1). This variation in seed weight is probably due to the dominating effect of umbel order. In fact, primary umbels appear first but mature at the same time with other

Table 1

Effect of mother root size and umbel order on seed yield and quality

Mother root size	Umbel order				Mean
	Primary	Secondary	Tertiary	Whole plant	
		1000 seed weight [g]			
Large	3.16 [a*]	2.57 [c]	2.11 [e]	2.44 [d]	2.57 [a*]
Very large	2.79 [b]	2.45 [d]	2.10 [e]	2.57 [c]	2.48 [a]
Mean	2.97 [a*]	2.51 [b]	2.10 [c]	2.50 [b]	
		Seed yield per plant [g]			
Large	4.000 [c]	18.220 [b]	3.13 [c]	25.35 [a]	25.350 [a]
Very large	4.200 [c]	18.430 [b]	3.320 [c]	25.95 [a]	25.950 [a]
Mean	4.100 [c]	18.325 [b]	3.225 [c]	25.650 [a]	
		Seed water content [%]			
Large	9.23 [b]	9.66 [a]	8.75 [de]	8.79 [d]	9.11 [a]
Very large	8.85 [cd]	8.50 [e]	9.29 [b]	9.09 [bc]	8.93 [a]
Mean	9.04 [a]	9.08 [a]	9.02 [a]	8.94 [a]	
		Seed germination [%]			
Large	90.50 [a]	86.50 [abc]	82.00 [cde]	82.50 [cde]	85.37 [a]
Very large	88.00 [ab]	85.50 [bcd]	79.50 [e]	81.00 [de]	83.50 [a]
Mean	89.25 [a]	86.00 [b]	80.75 [c]	81.75 [c]	

*Any two means in a group not sharing a letter differ significantly at 5% level of probability (DMR test) umbel orders, therefore, these have more time to develop and seeds gain more weight.

Seed yield per plant was not influenced by the mother root size. As far as umbel order is concerned, whole plant gave a seed yield of 25.650 grams. In this the contribution of tertiary umbels was only 3.225, while that of primary umbel was 4.100 grams. The secondary umbels contributed the maximum with a share of 18.325 grams. This is interesting that, there was only one primary umbel as compared to several tertiary umbels, but its contributions in seed yield per plant was more, though statistically not different (Table 1). Although the primary umbel is bigger in size with large sized and heavier seeds but the secondary umbels are medium sized with maximum contribution towards seed yield per plant, which might be attributed to their higher number. Regarding the interaction between these two factors, the combinations clearly demonstrated the supremacy of secondary umbel order with its highest share towards the seed yield per plant (Table 1). As primary umbel is only one and number of secondary umbels varies, therefore, the seed yield per plant is positively correlated with the number of secondary umbels. The maximum contribution of secondary umbels towards seed yield per plant is possibly due to their higher number per plant and heavy seed weight. These results are also in accordance with the findings of Sharma and Singh (1980).

Water content in the seed produced from large sized and very large sized roots was statistically same. Similarly, umbel order has no significant effect on seed water content (Table 1). In fact, seed water content depends upon the physiological maturity of the seed and weather conditions. However, it is interesting to record that the seeds from secondary umbel and larger sized roots contained the highest water content, whereas the seed from the same type of umbel but originating from very large sized roots had the lowest water content (Table 1). The phenomenon is very hard to describe because similar umbel types from different root sizes are exhibiting a wavering response.

Seed germination was not influenced significantly by the mother root size. However, germination of the seeds harvested from different umbel orders differed significantly. The seed from primary umbels gave the highest germination percentage followed by that from secondary umbels but these were statistically different. The seeds from whole plant and tertiary umbels gave the minimum germination percentage (Table 1). These findings agree with the findings of several other workers (Castro and Andrews 1971, Villeneuve *et al.* 1992, Satyaveer *et al.* 1994, Amjad and Anjum 2001). A perusal of interaction between mother root size and umbel order exhibits that the highest germination percentage was recorded in seeds of primary umbels and large sized roots followed by the seeds of primary umbels and very large sized roots and also by the seeds of secondary umbels and large sized roots. These three combinations also behaved statistically alike. The seeds from tertiary umbels and very large sized roots resulted in the minimum germination percentage (Table 1). The supremacy of former combinations is due to the impact of umbel order indicating that umbel order plays an important role in the seed germination. In fact, the seeds from primary umbels are bigger in size with well-developed embryo and more stored food, ultimately resulting in more germination percentage.

Root characteristics

Mother root size had no effect on the root length. However, umbel order had a significant effect on root length (Table 2). The longest roots were produced from the seed harvested from primary umbel followed by those produced from the seed of secondary umbels. These two treatments also stood at par. The smallest root length was recorded in those plants, which were raised from the seed of tertiary umbels. These results are in conformity with our previous findings (Amjad and Anjum 2001). In case of interaction, the maximum root length was recorded in primary umbel and large sized roots followed by whole plant umbel and very large sized roots. The minimum root length was recorded in tertiary umbels and large sized roots (Table 2). Like root length, root diameter was also not statistically influenced by the mother root size but was significantly affected by the umbel order (Table 2). The umbel order and interaction means for the parameter followed the same pattern as in the case of root length. This indicates that the seed of good quality (i.e. with more seed weight and high germination percentage) will result in longer and thicker roots.

Table 2

Effect of mother root size and umbel order on root growth and yield

Mother root size	Umbel order				Mean
	Primary	Secondary	Tertiary	Whole plant	
Average root length [cm]					
Large	21.35 [a*]	19.79 [cd]	16.45 [g]	18.75 [e]	19.08 [a]
Very large	19.55 [d]	19.89 [c]	17.46 [f]	20.70 [b]	19.40 [a]
Mean	20.45 [a]	19.84 [ab]	16.95 [c]	19.72 [b]	
Average root diameter [cm]					
Large	3.55 [a]	3.32 [c]	2.75 [f]	3.14 [d]	3.19 [a]
Very large	3.30 [c]	3.45 [b]	2.88 [e]	3.17 [d]	3.20 [a]
Mean	3.42 [a]	3.38 [ab]	2.81 [c]	3.15 [b]	
Average root weight [g]					
Large	153.58 [a]	142.58 [b]	96.92 [f]	127.33 [c]	130.04 [a]
Very large	126.34 [c]	154.09 [a]	105.34 [e]	120.34 [d]	126.54 [a]
Mean	139.96 [a]	148.33 [a]	101.13 [c]	123.83 [b]	
Root yield [t/ha]					
Large	38.592 [a]	36.276 [c]	30.186 [g]	32.933 [e]	34.497 [a]
Very large	37.542 [b]	33.840 [d]	28.682 [h]	31.094 [f]	32.789 [a]
Mean	38.067 [a]	35.058 [ab]	29.434 [c]	32.013 [bc]	

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

Average root weight had no significant response to mother root size. However, umbel order had a direct influence on the parameter. The maximum weight per root was recorded in the roots originating from the seed of secondary umbels and primary umbels and both these treatments behaved statistically alike. The minimum root weight was obtained in the roots produced from the seed of tertiary umbels (Table 2). Variation in root weight in accordance with seed size has already been reported earlier (Benjamin 1984, Sokolowska *et al.* 1995). The interaction means indicate that the heaviest roots were harvested from secondary umbels and very large sized roots and also from primary umbels and large sized roots and both these combinations stood at par. The minimum root weight was attained in case of tertiary umbel and large sized roots (Table 2). The higher root weight in former combinations was possibly due to the good quality seed source i.e. from primary and secondary umbels.

The root yield per unit area was not affected by the mother root size, but umbel order had a significant impact on the root yield. Seed harvested from primary and secondary umbels gave high yields in terms of carrot roots. Both these treatments were statistically at par. Seed from tertiary umbels was poor yielding (Table 2). In case of interaction between these two factors, the combination primary umbel and large sized root out yielded all other seed sources. The minimum seed yield was recorded in case of whole plant and very large sized root (Table 2). The results indicate that by using good quality seed (i.e. from primary and secondary umbels), higher root yield can be taken. Hence, the results of the present study are in accordance with the findings of Sokolowska *et al.* (1995). Good quality seed has more stored food, gives better germination and plant growth and ultimately resulting in higher root yield.

CONCLUSIONS

The results demonstrate that the mother root size had no significant effect on the yield and quality of seed and resulting roots. This indicates that the development of extra large roots might not be due to the inherent genetic potential but as a result of more space and proper nutrient availability and hence less competition among the plants. Therefore, it is better to sell/consume extra large roots and to use other category of roots for seed production. However, umbel order had a significant effect on the yield and quality of seed and resulting roots. The overall performance of the seed from primary umbels was better followed by that from secondary umbels. Therefore, it is recommended that during the seed production, tertiary umbels should be removed and/or seed from only primary and secondary umbels should be harvested to get higher root yield of better quality.

REFERENCES

Ahmad, N., Tanki, M.I. 1997. Effect of planting date, spacing and steckling size on growth and seed yield of carrot (Daucus carota L.). Hayana J. Hort. Sci. 26: 274-276.

Amjad, M., Anjum, M.A. 2001. Effect of root size, plant spacing and umbel order on the quality of carrot seed. Int. J. Agric. & Biol. 3: 239-242.

Benjamin, L.R. 1984. The relative importance of some sources of root-weight variation in carrot crop. J. Agric. Sci. 102: 69-77.

Castro, L.A.B.De, Andrews, C.H. 1971. Factors influencing the yield and quality of carrot seed. Arqu. Univ. Fed. Rural Rio de Janeiro 1: 19-28 [Hort. Abst. 43(9): 6113; 1973].

El-Adgham, F.I., El-Shal, M.A., Feleafel, M.N. 1995. A note on correlation studies in seed production of carrot var. Chantenary Red Cord. Alexandria J. Agric. Res. 40: 399-408.

Gill, S.S., Singh, H., Singh, J. 1981. Carrot seed production. II. Spacing and umbel order on seed yield. Veg. Sci. 8: 6-11.

International Seed Testing Association (ISTA). 1985. International rules for seed testing. Seed Sci. & Technol. 13: 338-341.

Krarup, H.A., Duran, A.L. 1982. Carrot seed production. VIII. Effect of pruning umbels on seed yield and quality. Agro Sur 10: 97-101 [Hort. Abst. 53(9): 6562: 1983].
Malik, Y.S., Singh, K.P., Yadav, P.S. 1983. Effect of spacing and number of umbels on yield and quality of seed in carrot (*Daucus carota* L.). Seed Res. 11: 63-67.
Petersen, R.G. 1994. Agricultural Field Experiments - Design and Analysis. Marcel Dekker, Inc., New York.
Saharan, B.S., Malik, Y.S., Baswana, K.S. 1993. Carrot seed quality as influenced by different root age, size, spacing and floral set. Haryana J. Hort. Sci. 22: 218-221.
Satyaveer, S., Nehra, B.K., Malik, Y.S. 1994. Carrot seed yield and quality as influenced by different order umbels under varying nitrogen, plant density and geometry. Crop Res. 8: 543-548.
Sharma, S.K., Singh, I.S. 1980. A note on correlation studies in seed production of carrot variety Pusa Kesar. Prog. Hort. 12: 81-83.
Sokolowska, A., Janas, R., Woyke, H. 1995. Effect of seed size on carrot root yield. Inst. Warzywnicta, Skierniewice, Poland, pp. 677-681 [Hort. Abst. 67(1): 506: 1997].
Szafirowska, A.I. 1994. The correlation between mother plant architecture, seed quality and field emergence of carrot. Acta Hort. 354: 93-97.
Tamet, V., Boiffin, J., Durr, C., Souty, N. 1996. Emergence and early growth of an epigeal seedling (*Daucus carota* L.): influence of soil temperature, sowing depth, soil crusting and seed weight. Soil & Tillage Res. 40: 25-38.
Verma, T.S., Ramesh, C., Lakhanpal, K.D., Joshi, S. 1993. Effect of root size and umbel order on yield and quality of carrot (*Daucus carota* var. *sativus*) seeds. Indian J. Agric. Sci. 63: 574-577.
Villeneuve, F., Luneau, C., Bose, J.P. 1992. Influence of seed size of carrot (*Daucus carota*) on germination and emergence. Acta Hort. 354: 55-56.