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INFLUENCE OF MOTHER ROOT SIZE AND PLANT SPACING ON CARROT SEED PRODUCTION

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Abstract: Mother root size used had no significant effect on sprouting of stecklings, subsequent growth and seed yields. Plant spacing had significant influence on number of branches per plant from the base and seed yields per plant and per hectare. Maximum number of branches was produced in case of wider spacings (i.e. 45 and 30 cm). Highest seed yield per plant was recorded in widest spacing (i.e. 45 cm). However, seed yield per hectare was highest in closest plant spacing (15 cm). While, sprouting percentage of stecklings, plant height at flowering stage and average seed weight per umbel had no significant response to these plant spacings. As far as the interaction between these factors is concerned, stecklings either from very large sized roots or from large sized roots and planted in widest spacing resulted in the highest seed yield per plant. However, the highest seed yield per hectare was obtained from the combinations; very large sized roots x the closest spacing and large sized roots x the closest spacing due to more number of plants per hectare.

Keywords: Carrot, *Daucus carota*, planting distance, root size, stecklings, seed yield, umbel order.

INTRODUCTION

Carrot (*Daucus carota* var. sativus, family Umbelliferae) is a very common vegetable of winter season and grown throughout the Pakistan. It is cultivated in the country on an area of 11,000 hectares with a total production of 1,92,000 metric tonnes carrot roots [Anonymous 1999]. Pakistan is one of the countries in the world, which is enjoying all seasons, due to which it is considered as an ideal region for producing vegetable seeds. There are two methods to produce carrot seed in the world, i.e. seed to seed and root to seed method. In Pakistan root to seed is the standard method for production of high quality seed as the technique allows to select healthy and true to type roots for replanting of stecklings. If the seed quality is not good, it may again be difficult to get enough number of uniform roots. One of the major problems faced by carrot growers in Pakistan is the unavailability of required amount of seed of good quality. The yield of carrot seed can be improved by adopting improved agronomic practices, particularly by using healthy planting material and proper planting distance. A lot of work has been conducted on production technology but a very little work has been carried out on carrot seed production. Relationship between harvest index and plant density in carrot seed production is very useful in optimising plant population for maximum seed yield and quality [Oliva *et al*. 1988]. Greater the plant density, greater will be the carrot seed yield but seed quality will

be poor [Noland *et al*. 1988]. However, stecklings from large sized roots of carrot produce higher yields/ha [Verma *et al*. 1993]. Satyaveer *et al*. [1994] found that high density planting in paired rows affected seed weight and vigour adversely in comparison with low density planting. El-Adgham *et al*. [1995] stated that seed yield/plant was significantly positively correlated with the number of second order umbels and with the total number of umbels/plant but the plant height was negatively correlated with seed yield parameters. Ahmad and Tanki [1997] observed that the stecklings planted before fall resulted in higher seed yield, taller plants, more number of secondary and tertiary umbels per plant and higher weight and size of secondary and tertiary umbels. Wider spacing (60 x 60 cm) resulted in more number of umbels, higher umbel weight and better umbel size. The seed yield was however, higher at closer spacing (60 x 30 cm). Planting of full root resulted in higher seed yield, large primary umbels and more number of secondary umbels per plant. The results are quite confusing and no such work has been conducted to study the effect of these factors under the local conditions. The present research project was, therefore, envisaged to find out the effect of root size and spacing distance on carrot seed yield.

MATERIALS AND METHODS

Seed of carrot cultivar T-29 was obtained from the Ayub Agricultural Research Institute, Faisalabad and sown at the Experimental Vegetable Area, Department of Horticulture, University of Agriculture, Faisalabad during the year 1997. After 14 weeks, when roots were mature, the crop was uprooted. After selecting true to type roots, their tops and tips were cut off to get desired sized stecklings. Two root sizes used were very large (over 200 g in weight) and large (125 to 150 g in weight). 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 kept constant and maintained as 60 cm.

The experiment was laid out as factorial with randomised complete block design in three replications. The combinations of root sizes and planting distances were randomised in 8 plots in each replication. The net plot size was 1.5 x 1.8 m. First irrigation was applied just after planting of stecklings. The subsequent irrigations were given at an interval of 7-15 days keeping in view the weather conditions. The crop was hoed properly and kept free of weeds manually during the entire growth period. The crop was sprayed once with Methyl parathion to protect the crop from insect- pests like cutworms and thrips.

Following data were collected on different parameters of growth and productivity during course of the studies: sprouting percentage of stecklings, plant height at flowering (cm), number of branches per plant, seed weight per umbel (g), seed yield per plant (g) and seed yield per

hectare (kg). The data collected were analyzed statistically by constructing the analysis of variance tables. The treatment means were subjected to Duncan's Multiple Range Test at 5% probability for their comparison [Petersen 1994].

RESULTS AND DISCUSSION

SPROUTING PERCENTAGE OF STECKLINGS

Sprouting of the stecklings was not significantly affected by the mother root size, plant spacing and their interaction (Tables 1 to 3). This indicates that size of roots used to prepare the stecklings and plant spacing followed had no effect on the sprouting percentage of stecklings.

Table 1: Effect of root size on growth and seed yield in carrot.

Growth and seed yield parameters	Root size	
	Very large	Large
Sprouting of stecklings (%)	84.03 a*	86.25 a
Plant height at flowering (cm)	1.49 a	1.33 a
No. of branches per plant	3.11 a	2.94 a
Average seed weight per umbel (g)	1.826 a	1.779 a
Seed yield per plant (g)	13.922 a	13.754 a
Seed yield per hectare (kg)	878.817 a	868.788 a

Table 2: Effect of planting distance on growth and seed yield in carrot.

Growth and seed yield parameters	Plant to plant distance			
	15 cm	22.5 cm	30 cm	45 cm
Sprouting of stecklings (%)	82.50 a*	82.64 a	81.66 a	93.75 a
Plant height at flowering (cm)	1.36 a	1.42 a	1.40 a	1.46 a
No. of branches per plant	2.14 b	2.72 b	3.55 a	3.68 a
Average seed weight per umbel (g)	1.756 a	1.839 a	1.751 a	1.865 a
Seed yield per plant (g)	9.393 d	13.153 c	14.349 b	18.457 a
Seed yield per hectare (kg)	1042.612 a	973.340 b	796.353 c	682.904 d

Table 3: Effect of root size and planting distance (interaction) on growth and seed yield in carrot.

Growth and seed yield parameters	Very large sized roots				Large sized roots			
	15 cm	22.5 cm	30 cm	45 cm	15 cm	22.5 cm	30 cm	45 cm
Sprouting of stecklings (%)	80.00 a*	81.12 a	83.33 a	91.67 a	85.00 a	84.16 a	80.00 a	95.83 a
Plant height at flowering (cm)	1.42 a	1.49 a	1.50 a	1.55 a	1.30 a	1.35 a	1.30 a	1.37 a
No. of branches per plant	2.16 a	2.80 a	3.72 a	3.76 a	2.12 a	2.64 a	3.38 a	3.60 a
Average seed weight per umbel (g)	1.790 a	1.830 a	1.817 a	1.868 a	1.722 a	1.849 a	1.685 a	1.861 a
Seed yield per plant (g)	9.485 d	12.996c	14.714b	18.489a	9.301 d	13.31c	13.984bc	18.424a
Seed yield per hectare (kg)	1052.824a	961.72b	816.616c	684.108d	1032.40a	984.96b	776.090c	681.70d

*Any two means in a row sharing similar letters are statistically non-significant at 5% level of probability (DMR test).

PLANT HEIGHT AT FLOWERING

Data regarding plant height, at the time of flowering, could not reveal any level of significant difference between the root sizes, spacing distances and interaction between the root size and spacing distance. This indicates that plant height is not affected by the mother root size, planting distance and the interaction between these two factors (Tables 1 to 3). Gray [1981] has already reported that plant density have no significant influence on plant height.

NUMBER OF BRANCHES PER PLANT

Results concerning this parameter exhibited highly significant differences for the different spacing distances, while no level of significant difference was observed for the root sizes and the interaction between these two factors. The individual comparison of plant spacing means demonstrate that wider spacings i.e. 45 cm and 30 cm resulted in more number of branches per plant as compared to the close plant spacings i.e. 15 cm and 22.5 cm (Table 2). This indicates that number of branches is influenced by plant spacing, wider the spacing, greater will be the number of branches per plant, probably due to availability of more space to grow and less competition for nutrients, light and air between the plants.

AVERAGE SEED WEIGHT PER UMBEL

Data procured on the seed weight of umbels depicted non-significant difference between the root sizes, plant spacings and interaction between the root sizes and spacing distances (Tables 1 to 3). Individual comparison of means of root size shows that mother root size used had no significant effect on seed weight per umbel. Similarly, spacing distances did not differ significantly from each other (Table 2). Ahmad and Tanki [1997] recorded higher umbel weight, umbel size and more number of umbels in wider spacing (60 x 60 cm). In carrot, umbels of different orders vary in number, size and seed weight. The primary umbel is only one per plant while the number of primary and secondary umbels depends upon the plant spacing. When plant spacing is increased, the number of umbels per plant and seed weight per umbel increases, therefore, average weight per umbel remains almost the same. In the present study, though seed yield per plant was highest in widest spacing but due to more number of umbels per plant, the average seed weight per umbel was not affected. As in carrot, seed weight depends upon the umbel order; therefore, average seed weight per each type of umbel order was also estimated. The results indicated that the maximum seed weight per umbel was recorded in case of primary umbels, which significantly differed from secondary and tertiary umbels (Table 4). The tertiary umbels resulted in minimum seed weight, which is due to their

smaller size and less time available to develop. These results are in conformity with the findings of Nath and Kalvi [1969].

Table 4: Effect of umbel order on seed yield in carrot.

Umbel order	Seed weight per umbel (g)	Seed yield per plant (g)
Primary umbel	4.000 a*	4.000 b
Secondary umbel	2.880 b	8.640 a
Tertiary umbel	0.330 c	1.200 c

*Any two means in a column sharing similar letters are statistically non-significant at 5% level of probability (DMR test).

SEED YIELD PER PLANT

Data procured for seed weight per plant was subjected to statistical analysis which elucidated that the mother root sizes did not differ significantly, while the spacing distances and means of the interaction between root sizes and spacing distances differed significantly with each other. Individual comparison of root sizes shows that the seed yield per plant is not influenced by the mother root size used (Table 1). Results of the present study are in contrast with Paradisi and Montanari [1985] who reported significant increase in seed yield with increasing root diameter and also with Ahmad and Tanki [1997], who found that planting of full root resulted in higher seed yield possibly due to the use of differential root sizes. A comparison of spacing distances showed a decline in the seed weight per plant by reducing planting distance. The widest spacing (45 cm) proved to be the most optimum spacing distance with highest seed yield per plant. The lowest seed yield per plant was obtained in closest spacing (15 cm). The other two spacings (i.e. 30 and 22.5 cm) fell in between the maximum and minimum (Table 2). This indicates that increasing the plant to plant distance will result in more yield per plant. Gill *et al*. [1981] reported that 60 x 45 cm spacing was found to be significant to produce more number of umbels and gave higher seed yield per plant. The interaction among the root sizes x plant spacings indicated that highest seed yield per plant was obtained from the combination; very large sized roots x 45 cm plant spacing and large sized roots x 45 cm plant spacing. Both these combinations behaved statistically alike. This might be because the plants had better opportunity to grow in wider spacings, ultimately resulting in more seed yield per plant as compared to those in closer spacings. The minimum seed yield per plant was obtained from the combinations; large sized roots x 15 cm plant spacing and very large sized roots x 15 cm plant spacing (Table 3). Seed yield in carrot depends upon the number of primary, secondary and tertiary umbels, which differ in seed weights. Studies on seed setting in cv. Imperator revealed that seeds are set in 100 % primary and secondary umbels whereas, 82.7 % in case of tertiary umbels [Sadhu 1993]. As primary umbel is only one while number of secondary umbels varies, therefore, the seed yield per plant is positively correlated with the number of

secondary umbels. A review of three umbel order means indicates that secondary umbels contributed maximum towards seed yield per plant, while the tertiary umbels minimum and primary umbels remained in between these two (Table 4). This might be due to more number of secondary umbels per plant and their heavy seed weight. These results are also in accordance with the findings of Sharma and Singh [1980].

SEED YIELD PER HECTARE

The seed yield per hectare was calculated from seed yield per plant and number of plants per hectare. Data recorded on this parameter revealed non-significant difference between the root sizes (Table 1) and significant difference between spacing distances and interaction between the root size and spacing distance. It indicates that seed yield per hectare is not influenced by size of the roots used to produce seed. These results are in contrast to Digole and Shinde [1990], who reported that seed yield increased significantly with increasing root diameter. The difference could be due to different root sizes they used. However, in the present study, stecklings prepared from very large and large roots behaved statistically alike and remained at par. In case of plant spacings, maximum seed yield per hectare was recorded in the closest spacing (15 cm), which differed significantly from other spacings. As plant-to-plant distance was increased, the yield per hectare was decreased (Table 2). Since the major contributions towards yield are by the primary and secondary umbel orders, their number per unit area can be increased by closer spacing. Planting the stecklings at closer spacing has been found to be quite beneficial for increasing the seed yield of carrot [Saini and Rastogi 1976]. The highest seed yield in the closest spacing might be due to more number of plants. At the highest densities, about 60 % of the seed yield was contributed by the primary umbels as compared to less than 20 % at the lowest plant density [Gray 1981]. Malik *et al.* [1983] obtained highest seed yield of carrot (10.9 to 11 q ha^{-1}) from closely spaced plants (45 x 20 cm) with all umbels left to set seed. Gray [1981] has also reported similar results stating that when plant density was increased from 100,000 to 800,000 plants ha^{-1}, seed yield increased from 1100 to 1500 kg ha^{-1}. Hence, results of the present study are in conformity with previous workers. As far as the interaction between these two factors is concerned, the highest seed yields were recorded from the combinations; very large sized roots x the closest spacing (15 cm) and large sized roots x the closest spacing. However, both the root sizes at wider spacings performed poorly with lower seed yield per hectare. The highest seed yield in the closest spacing may be attributed to highest number of plants per hectare and more number of primary and secondary umbels.

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