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Effect of Spacing and Steckling Size on Seed Yield and its Attributing Parameters in Carrot (*Daucus carota* L.)

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ABSTRACT: The study was conducted to assess the effect of spacing and steckling size on seed yield and seed yield attributing characters of carrot, *cv.* Hisar Gairic, at Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2018-19. The results revealed that maximum seed yield (7.62q/ha) was obtained with plant spacing of 60 x 45 (Paired row on ridge) which was statistically at par (7.39q/ha) with plant spacing of 60 x 30 cm (Single row on ridge). Among the steckling lengths, maximum seed yield (7.01q/ha) was recorded with steckling length of 8cm while yield was minimum (6.03q/ha) with steckling length of 4cm. Other yield attributing characters such as number of seeds per primary umbel (2058), number of seeds per secondary umbel (1538), seed yield per primary umbel (3.19g), seed yield per secondary umbel (2.20g), seed yield per plant (18.39g), test weight (1.97g) and seed yield (7.01q/ha) were also recorded maximum with steckling size of 8 cm. It is concluded from the study that plant spacing of 60x45 (Paired row on ridge) and steckling size of 8 cm is optimum for higher seed yield in carrot.

Keywords: Carrot, Hisar Gairic, Plant spacing, Steckling size, Umbel

Carrot (*Daucus carota* L.) is a popular cool season vegetable cultivated in tropical region during winter. Carrot with chromosome number 2n=18 belonging to the family Umbelliferae is one of the important root vegetable crop used as salad, cooked vegetable, canned pickles, preserves, sweets (specially gajar-halwa), carrot powders, kanji; an appetizing drink; *etc.* [2].

It contains significant amount of carotene (10 mg/100 g), thiamine (0.04 mg/g) and riboflavin (0.05 mg/g) [13]. It is also an excellent source of iron, carbohydrate vitamin-B, vitamin-C and sugar. It produces edible root of high quality in one season and seed in two seasons. Its cultivated forms have been domesticated from wild species. The edible part of carrot is enlarged fleshy taproot consisting of cortex (phloem) and core (xylem). Good quality carrot roots have a maximum of cortex and minimum of core.

Carrot is grown worldwide mainly in south western Asia, especially in Afghanistan. Similarly the wild forms are also seen in Europe. In India, it covers an area of 86 thousand hectares with annual root production of 1379 thousand tonnes, while in Haryana, which is the leading producer of carrot in India, the area under this crop is 28.05 thousand hectare with root production of 420.50 thousand tonnes [1].Carrot is grown from true seeds and its successful production is dependent upon a sustainable and satisfactory supply of good quality seed. However, the seed supply from the domestic production is not adequate and growers depend mainly on imported seeds that demand foreign currency and are of questionable sources with respect to germination and susceptibility to diseases [8]. Thus, to improve the production and productivity of carrot domestically, the availability of quality seed is crucial.

India 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. Though there are two methods of carrot seed production *i.e.*, seed to seed and root to seed method but root to seed method is good for quality seed as this method allows for the selection of healthy and true to type roots for the planting 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 India is the unavailability of required amount of good quality seed. The yield of carrot seed can be increased by using healthy planting material and proper planting distance. A lot of work has been conducted on production technology but a little work has been carried out on carrot seed production. The relationship between harvest index and plant density in carrot seed production is very useful in

Table 1. Mean monthly meteorological data during the study

Months	Weeks	Temperature (ºC)		Relative humidity (%)		Evaporation (mm)	Rainfall (mm)
		Maximum	Minimum	Morning	Evening		
October	41	32.5	17.9	86	43	3.7	0.0
	42	33.4	16.5	72	30	3.7	0.0
	43	31.4	14.4	83	36	2.9	0.0
November	44	31.0	15.4	92	44	2.4	0.0
	45	27.4	10.1	90	41	2.1	0.0
	46	27.5	12.7	91	53	1.9	0.0
	47	27.4	10.9	87	44	2.3	0.0
December	48	27.2	9.4	93	46	1.7	0.0
	49	24.9	7.5	96	45	1.2	0.0
	50	21.0	7.7	91	57	1.4	0.0
	51	20.7	2.0	93	50	1.2	0.0
	52	19.8	1.9	94	49	0.9	0.0
January	1	18.9	5.7	95	66	0.9	7.3
	2	19.3	5.6	93	60	0.9	0.0
	3	20.4	4.9	90	55	1.0	0.0
	4	18.2	4.8	99	63	1.1	6.5
February	5	17.1	5.3	96	65	1.1	0.0
	6	21.0	6.9	92	56	1.6	0.0
	7	20.0	9.7	94	67	1.2	0.0
	8	22.2	9.0	89	50	2.1	0.0
March	9	20.9	8.0	93	53	1.9	14.8
	10	24.2	8.5	88	38	2.7	0.0
	11	24.9	9.1	91	48	2.6	0.0
	12	28.9	11.8	80	42	4.0	0.0
	13	32.6	13.5	81	28	3.7	0.0
April	14	36.0	16.0	74	28	5.4	7.3
	15	36.9	20.0	69	27	6.4	0.0
	16	32.9	17.2	81	37	5.8	8.2
	17	40.7	20.6	56	19	8.3	0.0
May	18	40.1	20.8	48	23	8.9	0.0
	19	40.5	21.7	48	20	8.0	0.0
	20	35.7	20.5	82	37	6.5	59.8
	21	38.0	22.7	61	26	6.2	0.0

Source: Department of Agricultural Meteorology, CCS HAU, Hisar

optimizing plant population for maximum seed yield and quality [11]. Greater the plant density, greater will be the carrot seed yield but the quality of seed will be poor [10], however, stecklings from larger roots of carrot give higher yield per hectare [16]. High density planting in paired rows affected seed size and vigour adversely in comparison with low density planting. Wider spacing (60 x 60 cm) resulted in more number of umbels, higher umbel weight and better umbel size. However, the seed yield was higher at closer spacing (60x30 cm). Planting of full root resulted in higher seed yield, large primary umbels and more number of secondary umbels per plant [12]. No such work has been conducted to study the effect of these factors under Haryana conditions. Therefore, the present study was envisaged to find out the effect of plant spacing and steckling length on seed yield and yield attributing characters of carrot.

MATERIALS AND METHODS

The present study was carried out on carrot, cv. Hisar Gairic, at Seed Research Area of Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana during 2018-19 situated at 29°10' North Latitude and 75°46' East Longitude at an elevation of 215.2 m above mean sea level on south western border of the Rajasthan. The seed production was done by “Root to Seed” method in Factorial Randomized Block Design replicated thrice with

five plant spacings *i.e.* 60x30 cm (Flat)**,** 60x45 cm (Flat), 60x60 cm (Flat)**,** 60x30 cm (Single row on ridge), 60x45 cm (Paired row on ridge) and three steckling lengths *i.e.* 4, 6 and 8 cm. The recommended plant protection measures, thinning, rouging and monitoring operations were also adopted as and when required for raising healthy roots. The foliage was cut keeping one third only. The roots were cut with sharp knife and the stecklings were prepared as per treatments. The observations on number of seeds per primary umbel, number of seeds per secondary umbel, seed yield per primary umbel (g), seed yield per secondary umbel (g), seed yield per plant (g), test weight (g) and seed yield (q/ha) were recorded. Primary umbels (produced on main stem) and secondary umbels (produced on secondary branches) from each tagged plants from each treatment and each replication were harvested separately. The umbels were then dried, threshed and seeds were counted to calculate the number of seeds per primary and secondary umbel. After that seed was weighed to calculate the seed yield per primary and secondary umbel expressed in grams (g). Total seed yield obtained from ten observational plants from primary and secondary umbels, respectively from each treatment in each replication was used for computation of seed yield on plant basis and measured in grams. Seed yield of each plot was later converted to quintals per hectare. From the sample drawn for each order umbel from each plot, 1000 seeds were counted each from primary and secondary umbels and their weight was calculated in electronic balance to get test weight in gram. The statistical analysis was carried out by using the online statistical tool (OPSTAT) developed by [14].

RESULTS AND DISCUSSION

The results revealed that seed yield and yield attributing characters varied significantly with plant spacings and sizes of steckling. Maximum number of seeds per primary umbel (2425) and per secondary umbel (1858) were observed under 60x30cm (Flat) plant spacing (Table 2). Seed yield per primary umbel (3.67g) and seed yield per secondary umbel (2.67g) were recorded maximum at 60x60cm (Flat) spacing (Table 3). Seed yield (q/ha) was recorded maximum (7.62q/ha) in 60x45 cm (Paired row on ridge) (Table 4). This may be due to difference in test weight. The results depicted that seed yield increased with the increase in steckling size. Maximum number of seeds per primary umbel (2058), number of seeds per secondary umbel (1538), seed yield per primary umbel

Table 2. Effect of plant spacing and steckling size on number of seeds in primary and secondary umbel of carrot

Spacing (SP)	Number of seeds per primary umbel				Number of seeds per secondary umbel			
	Steckling size (SZ)							
	4 cm	6 cm	8 cm	Mean	4 cm	6 cm	8 cm	Mean
60x30cm (Flat)	2291	2436	2548	2425	1686	1919	1968	1858
S_2=60x45cm (Flat)	1688	1768	1809	1755	1251	1301	1317	1290
60x60cm (Flat)	1514	1596	1618	1576	1062	1193	1210	1155
60x30cm (Single row on ridge)	1893	1982	2090	1989	1328	1452	1530	1436
60x45cm (Paired row on ridge)	2102	2168	2224	2164	1574	1601	1662	1612
Mean	1898	1990	2058		1380	1493	1538	
C.D. at 5%	SP (29.38), SZ (22.76), SPx SZ (50.89)				SP (27.33), SZ (21.17), SPx SZ (47.34)			

Table 3. Effect of plant spacing and steckling size on Seed yield of primary and secondary umbel of carrot

Spacing (SP)	Seed yield per primary umbel (g)				Seed yield per secondary umbel (g)			
	Steckling size (SZ)							
	4 cm	6 cm	8 cm	Mean	4 cm	6 cm	8 cm	Mean
60x30cm (Flat)	2.55	2.67	2.72	2.65	1.84	1.92	2.05	1.94
60x45cm (Flat)	3.15	3.21	3.28	3.21	2.45	2.56	2.62	2.54
60x60cm (Flat)	3.35	3.75	3.90	3.67	2.50	2.71	2.81	2.67
60x30cm (Single row on ridge)	2.97	3.04	3.14	3.05	2.18	2.34	2.36	2.29
60x45cm (Paired row on ridge)	2.80	2.90	3.04	2.92	1.05	1.07	1.14	1.09
Mean	2.96	3.15	3.19		2.00	2.12	2.20	
C.D. at 5%	SP (0.05), SZ (0.04), SPx SZ (0.09)				SP (0.04), SZ (0.03), SPx SZ (0.07)			

Table 4. Effect of plant spacing and steckling size on seed yield of carrot

Spacing (SP)	Seed yield per plant (g)				Seed yield (q/ha)			
	Steckling size (SZ)							
	4 cm	6 cm	8 cm	Mean	4 cm	6 cm	8 cm	Mean
60x30cm (Flat)	7.13	8.41	9.02	8.19	4.21	4.84	5.06	4.70
60x45cm (Flat)	17.04	20.68	21.21	19.64	6.15	7.22	7.37	6.91
60x60cm (Flat)	22.48	25.29	26.16	24.64	5.79	6.76	6.97	6.51
60x30cm (Single row on ridge)	16.05	18.48	19.00	17.84	6.70	7.68	7.79	7.39
60x45cm (Paired row on ridge)	13.16	15.84	16.56	15.19	7.31	7.70	7.87	7.62
Mean	15.17	17.74	18.39		6.03	6.84	7.01	
C. D. at 5%	SP (0.06), SZ (0.05), SPx SZ (0.12)				SP (0.25), SZ (0.19), SPx SZ (0.43)			

Table 5. Effect of plant spacing and steckling size of carrot on test weight (g)

Spacing (SP)	Steckling size (SZ)			
	4 cm	6 cm	8 cm	Mean
60x30cm (Flat)	1.39	1.61	1.62	1.54
S_2=60x45cm (Flat)	1.95	1.99	2.04	1.99
60x60cm (Flat)	2.03	2.35	2.40	2.26
60x30cm (Single row on ridge)	1.85	1.90	1.94	1.90
60x45cm (Paired row on ridge)	1.63	1.79	1.83	1.75
Mean	1.77	1.93	1.97	
C. D. at 5%	SP (0.08), SZ (0.06), SPx SZ (NS)			

(3.19g), seed yield per secondary umbel (2.20g), seed yield per plant (18.39g), test weight (1.97g) and seed yield (7.01q/ha) were recorded with steckling size of 8 cm while minimum number of seeds per primary umbel (1898), number of seeds per secondary umbel (1380), seed yield per primary umbel (2.96g), seed yield per secondary umbel (2.00g), seed yield per plant (15.17g), test weight (1.77g) and seed yield (6.03q/ha) were recorded with steckling size of 4 cm. The size of stecklings used in planting for seed production has also been reported to exert great influence on seed yield and is considered a key factor in carrot seed production. Higher seed yield with increased steckling size and highest seed yield per unit area with the use of medium and large size stecklings have been observed by [9] and [16]. Large steckling size has more accumulated food as compared to small steckling size which might have affected morphological characteristics of carrot which ultimately leads to more seed yield. Similar findings were reported by [6] in carrot, [4] in radish and [5] in radish.[3],[7],[9] and[15] reported that seed produced under wider plant spacing has highest test weight as compared to closer plant spacing. This might be due to better conditions of plant growth under wider spacing resulting in bold size seeds as compared to closer plant spacing. The steckling size of 8 cm produced significantly higher test weight which was statistically at par with steckling size of 6 cm. It may be due to better growth and availability of more photosynthates at the time of maturity, while, the growth was poor in case of small steckling size due to less availability of reserve food material. Although number of seeds per primary and secondary umbel was recorded maximum at 60x30cm (Flat) spacing and seed yield per primary and secondary umbel and test weight were recorded maximum at 60x60 cm (Flat) spacing but maximum seed yield per hectares was recorded at plant spacing of 60 x 45 (Paired row on ridge) with stecklings of 8 cm. Seed quality parameters were found better at plant spacing of 60 x 60 cm (Flat) with steckling size of 8 cm.

CONCLUSION

On the basis of present experiment, it may be concluded that maximum seed yield of carrot cv Hisar Gairic was obtained under plant spacing of 60x45 (Paired row on ridge) and steckling size of 8 cm is optimum for higher seed yield in carrot.

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