



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP5: 99-102

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(Special Issue- 5)
International Conference on
“Food Security through Agriculture & Allied Sciences”
(May 27-29, 2019)

Effect of plant density on seed production of carrot var. Hisar Gairic

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Abstract

Carrot is a popular cool season vegetable cultivated in tropical region during winter. Carrot belongs to the family Apiaceae with $2n=18$. It produces edible root of high quality in one season and seed in two seasons. Seed stalk is produced in second season. It is advisable to plant carrot seed crop at high plant density to ensure more proportion of seed yield with quality seed from primary and secondary order umbels. In this case, proper spacing can be maintained and after-care like weeding and thinning is easier. Prepared stecklings are planted either on flat bed or on ridge. Planting on ridges is more easy and convenient. In addition, there is no fear of water stagnation. The present experiment was conducted at Seed Area, Department of Vegetable Science, and in Laboratory of the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar (Haryana) during 2016-17 and 2017-18. The experiment was laid out in Randomized Block Design with three replications. There were five treatments of spacing i.e. T₁: 45x45 cm, T₂: 45x30 cm, T₃: 45x15 cm, T₄: 30x30 cm, T₅: Paired row (60x45 cm). The treatment S₅ (paired row) was significantly higher for umbels per plant (11.21), seed yield per plant (17.78 g) and seed yield per hectare (7.51 q), which was statically at par with treatment S₁ (45x45 cm).

Keywords: Carrot, plant density, seed production, paired row

Introduction

Carrot is a popular cool season vegetable cultivated in temperate countries mainly during spring and summer season while in tropical region during winter season. It is valued as a nutritive food mainly because of high carotene content. Carrots also possess anti-oxidant properties, fix up harmful free radicals and prevent heart diseases. Per 100 g carrot root has 86 g moisture, 10.6 g carbohydrates, 0.9 g protein, 0.2 g fat, 1890 µg beta-carotene, 0.04 mg thiamine, 0.02 mg riboflavin, 3.0 mg vitamin C, 80 mg calcium and 2.2 mg iron (Dhaliwal, 2008) [2]. It is used as salad, cooked and used in preparation of soups, stew etc. Tender roots are processed to make pickles, jam, candy, jellies and juice. Red type is good for preparing various types of sweets especially *Gajar Halwa* in Northern India. Black carrots are used for the preparation of a soft beverage called *Kanji*, which is supposed to be a good appetizer. It increases the quality of urine and helps the elimination of uric acid. Carrot seed oil is used for flavouring liquors and all kind of food substitutes. Carrot seeds are aromatic, stimulant and carminative.

The area under carrot crop in India is reported to be 86000 ha with an annual production of 13.79 lakh metric tonnes (NHB, 2016-17). South Western Asia, especially Afghanistan is considered the main centre of origin to this crop as largest morphological diversity has been found to occur in this region. Carrot is cultivated on a larger scale in China, Russia, USA, Uzbekistan, Poland, England, India, Malaysia, Indonesia, Philippines, Central, East and West Africa, South America and the Caribbean. It is the second most important vegetable in England after potato. In Australia, carrot is the third most important vegetable after potato and tomato. In India, the important carrot growing states are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana.

Carrot belongs to the family Apiaceae with $2n=18$. It produces edible root of high quality in one season and seed in two seasons.

The leaves are rosette, pinnately compound with long petiole. Seed stalk is produced in second season. The edible root is fleshy taproot consisting of cortex (phloem) and core (xylem). High quality carrot has a large cortex with minimum core. The inflorescence in carrot is compound umbel 'head' in which protoandry is present. Carrot is a cross pollinated crop. Because of this, natural selfing depends upon presence of insects to transfer pollen to receptive stigma. The pollinating agents are mainly honeybees and other insects belong to genera Hymenoptera, Diptera and Coleoptera. Carrot is grown from the true seeds and its successful production dependent upon a sustainable and satisfactory supply of good quality seed (McDonald and Copland, 1998) [5].

Relationship between harvest index and plant density in carrot seed production is very useful in optimizing plant population for maximum seed yield and quality (Oliva *et al.*, 1988) [10]. Greater the plant density, greater will be the carrot seed yield but seed quality will be poor (Noland *et al.*, 1988) [9]. It is advisable to plant carrot seed crop at high plant density to ensure more proportion of seed yield with high quality seed from primary and secondary order umbels. Planting ratio and plants spacing had a significant effect on seed yield (Kumar *et al.*, 2017) [4]. In this case, proper spacing can be maintained and after-care like weeding and thinning is easier. Prepared stecklings are planted either on flat bed or on ridge. Planting on ridges is more easy and convenient. In addition, there is no fear of water stagnation. Keeping in view the above facts in mind the present study was undertaken to assess the effect of plant density on quality seed production of carrot.

Materials and Methods

The present experiment was conducted at Seed Area, Department of Vegetable Science, and in Laboratory of the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar (Haryana) during 2016-17 and 2017-18. The general features of this region are semiarid climate with hot and dry winds during summer and dry severe cold in winter. The soil of the experimental field was sandy loam in texture with pH and EC of 8.2 and 0.39 dS/m, respectively. The experiment was laid out in Randomized Block Design with three replications. There were five treatments of spacing *i.e.* T₁: 45x45 cm, T₂: 45x30 cm, T₃: 45x15 cm, T₄: 30x30 cm, T₅: Paired row (60x45 cm).

The seed production of carrot was done by Root-to-Seed method and brief package of practices given below.

Preparation of roots for planting

Carrot seed of Hisar Gairic variety was sown in the month of mid-October, is the best time for sowing in Hisar condition. Seed was sown on the ridge at spacing of 7-8 cm for better development and quality of root. Recommended dose of fertilizers were applied at ambient time. Two or more hoeing was given at 40 and 65 days after sowing to control the weeds. The recommended plant protection measures, thinning and roguing operations were also adopted as and when required for raising healthy root crop.

Preparation steckling

Fully developed and healthy roots of the carrot was lifted with the help of digger. The whole foliage was cut leaving only one third to length (8-10 cm) and root cut leaving only 6-8 cm to its length.

Transplanting

After 2-3 deep ploughing or hoeing followed by planking and

the field is made to a fine, tilt flat beds of convenient size were made. Land to be used for seed production of carrot was free from volunteer plants. The carrot steckling were transplanted in the main field after about 100-110 days of sowing *i.e.*, mid of January month in spacing of as per treatments.

Nutrition

About 40-50 tonne of decomposed FYM was applied. Carrot is a heavy feeder of nutrients, especially of potash. A recommended dose of 40 kg potash along with 80 kg nitrogen and 40 kg phosphorous per hectare were also applied. Whole of phosphorous and potash and half of nitrogen were applied at the time of field preparation and the remainder of nitrogen 30-40 days after sowing.

Irrigation

Soon after transplanting irrigation was given so that the roots get established properly in the soil. After that irrigation was continued given at 7-10 days interval. Flowering and fruit setting are critical period for irrigation. Thereafter it has stopped to enhance umbel maturity.

Weed control

First shallow hoeing was done 3 weeks after planting of steckling. This operation simultaneously carried out with application of split dose of nitrogen fertilizer. The second interculture operation was applied 3 weeks after the first operation. Carrot normally grows slowly in the beginning and cannot compete with weeds. Stomp (pendimethalin) @ 2.5 l/hectare, as a pre-emergence application was applied to check weeds in carrot.

Roguing

The very first roguing was done during the preparation of stecklings. All off-type roots were discarded on the basis of shape, size, Color, healthy and unhealthy roots. Only true-to-type were remained as per Hisar Gairic characters. Second roguing is done during flowering and fruit setting stage. Third roguing is done at time of maturity *i.e.* before harvesting. Late maturing type of plants, the plants that are tall or dwarf *i.e.* they were distinct in size than the grown variety, have been removed.

Field inspection

A minimum of four inspections have made as follows:

1. The first inspection have made before flowering in order to determine isolation, volunteer plants, outcrosses and other relevant factors.
2. The second and the third inspections have made during flowering to check isolation, off-types and other relevant factors.
3. The fourth inspection have made at maturity to verify the true nature of umbel.

Drying and seed extraction

Carrot umbels harvesting have started in second fortnight of May. Carrot umbels were dried within 5-6 days on open sun after picking. The seeds was extracted by beating the dried umbels with sticks and then winnowed by blowing against the wind. The seeds was cleaned that there is no chaff of other inert matter. Cleaned seed was dried up to 8 per cent moisture.

Observations recorded: Plant height (cm), umbels per plant,

seed yield/plant (g), seed yield (q/ha), test weight (g), germination (%).

Statistical analysis

The data recorded on different parameters were subjected to statistical analysis in OPSTAT, statistical software developed by CCS Haryana Agriculture University, Hisar (Haryana), India and the mean differences were evaluated by critical difference (C.D.) test at 5% level of significance (Sheoran, 2010) [12].

Results and Discussion

Plant height (cm)

Plant height of carrot seed crop under spacing was recorded at final harvesting presented in Table-1. During experimentation, plant height increased progressively with the age of crop. Plant height of carrot seed crop varied

significantly due to spacing. Among spacing treatments maximum plant height was observed when the crop was planted on ridge in a paired row (128.94 cm) pooled mean of both year followed by S₁ (118.92 cm), while minimum plant height was with S₄ (110.54 cm).

Number of umbels per plant

Maximum number of umbels per plant was recorded with paired row (11.21) which was statistically at par with spacing S₁ (11.15), when the data was pooled for both years while minimum number of umbel was recorded with spacing S₃ (9.02) Table-1. It was probably due to high plant density to ensure more primary and secondary order umbels. Ahmad and Tanki (1997) [1] observed wider spacing (60 x 60 cm) resulted in more number of umbels, higher umbel weight and better umbel size.

Table1: Effect of planting densities on seed production of carrot

Spacing	Plant height (cm)			No. of umbels/plant (Pri.+Sec.)			Seed yield/plant (g)		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
S ₁ : 45 x 45 cm	121.50	116.33	118.92	11.90	10.40	11.15	18.11	17.09	17.60
S ₂ : 45 x 30 cm	125.70	108.33	117.02	11.50	9.32	10.41	13.66	12.17	12.92
S ₃ : 45 x 15 cm	128.30	105.67	116.97	9.90	8.13	9.02	7.58	5.63	6.61
S ₄ : 30 x 30 cm	123.40	97.67	110.54	11.30	7.20	9.25	9.03	6.50	7.77
S ₅ : Paired row (60x45 cm)	138.20	119.67	128.94	12.30	10.12	11.21	19.59	15.97	17.78
CD at 5%	7.80	4.19	5.12	0.60	1.10	0.71	3.43	1.37	2.04

Seed yield per plant (g) and per hectare (q): Maximum seed yield per plant (17.78 g) and per hectare (7.51 q) was recorded when carrot steckling was planted on ridge in a paired row, pooled mean of both year which was significantly at par with spacing S₁ (17.60 g) and (7.07 q). It was due to

higher number of umbels per plant and test weight of carrot seed. Similar results were reported by Sutradhar *et al.*, 2018; Mengistu and Yamouh, 2010; Muhammad and Muhammad, 2002) [13, 6, 7].

Table 2: Effect of planting densities on seed production of carrot

Spacing	Seed yield (q/ha)			1000 seed weight (g)		
	2016-17	2017-18	Mean	2016-17	2017-18	Mean
S ₁ : 45 x 45 cm	7.94	6.20	7.07	2.14	1.90	2.02
S ₂ : 45 x 30 cm	7.98	5.66	6.82	1.96	1.82	1.89
S ₃ : 45 x 15 cm	8.50	4.28	6.39	1.84	1.66	1.75
S ₄ : 30 x 30 cm	8.06	3.96	6.01	1.91	1.80	1.86
S ₅ : Paired row (60x45 cm)	8.93	6.08	7.51	2.20	1.86	2.03
CD at 5%	0.40	0.24	0.50	0.22	NS	0.12

Test weight (g): Higher value of test weight (1000 seed weight) was observed in paired row (2.03 g) which was statistically at par in spacing of S₁ (2.02 g), while, it was observed minimum in spacing of S₃ (1.75 g) Table-2. Higher test weight of carrot seed was probably due to size of seeds and umbel due to high plant density. Similar results were reported by Satyaveer *et al.* (1994) [11] that high density planting in paired rows affected seed weight and vigour adversely in comparison with low density planting. Jacobson and Globerson, 1980 [3], also support it.

Conclusion

Based on two-year study, it may be concluded that carrot seed crop (steckling) should be planted at ridge with paired row at spacing of 60x45 cm for higher quality seed yield followed by 45x45 cm (flat).

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