Standardization of Seed Production Technology of European Carrots in Cold AridTrans-Himalayan Ladakh Region of India

ABSTRACT

European carrot is one of the most emerging root vegetables grown in India. These are very rich in carotene content. In Ladakh, the cold arid mountainous region, European carrots are very popular for root production.European carrot has a special significance in cold arid regions like Ladakh where breeding and seed production of European/ temperate type can be done due to congenial and favourable climate. As the European carrots are biennial for seed production, the root crop was produced in first season(crop season of 2012) and seed crop was raised in the next season(crop season of 2013). Climate of the area is typically dry temperate. Experiment consisting of two dates of replanting (29 March and 28 April), four diameter groups of stecklings (<20mm; 20-25mm; 25-30mm and >30mm)and two varieties of European carrots(Early Nantes and Pusa Yamdagni) conducted in the split split plot design with three replications.Replanting of steckling on 29 April took statistically lesser days to flowering and seed maturity. Diameter group of stecklings (>30mm) exhibited significantly shortest time to flower and seed maturity as well as statistically highest seed yieldover all the other diameter groups except Diameter group (25-30mm). Carrot var. Early Nantes showed superiority for all the characters under study. Steckling diameter group (>30mm) x Variety E. Nantes produced statistically highest seed yield. Date of replant (29 March) x Diameter group (>30mm) x Variety E. Nantes generated highest seed yield. Carrot steckling replanting of variety Early Nantes in April with root diameter more than 25 mm is recommended for whole Ladakh region. Ladakh region can be a seed production hub of European carrots and requirement of seed import to India can be minimized if potential is tapped judiciously.

Keywords: Cold arid, diameter group, European carrot, Ladakh, seed yield

1. INTRODUCTION

Nature has endowed India with many precious gifts, wherein lies its immense potential for the vegetable sector. In the last three decades, India has witnessed a sea change in the scenario of vegetable seed production. Success of any seed production programme depends on the climate and agronomic practices taken to produce the healthy and vigorous crop. Among the agronomic practices, sowing at optimum time is considered as an important non-cash input that results in considerable increase in the yield and quality. Productivity of most of arable crops owing to change in the environmental conditions to which phenological stages of the crop are exposed. The modified environment resulting from different dates of sowing may thus influence the crop growth, flowering and seed development. If accidentally crop caught in unfavourable environment that will be detrimental to seed yield and quality [1].Carrot is an important vegetable crop grown in spring, summer and autumn in temperate regions and during winter in tropical and sub-tropical regions. Carrot seeds are rarely produced in tropical conditions since mean day temperatures are less than 20°C [2].

European carrot (*Daucus carota* L.), a member of family Umbelliferae is one of the most emerging root vegetables grown in India. These are very rich in carotene content. In Ladakh, the cold arid mountainous region, European carrots are very popular for root production. In plains, this type of carrot fetches premium price as compared to the Asiatic carrots. European carrot has a special significance in cold arid regions like Ladakh where breeding and seed production of European/ temperate type can be done due to congenial and favourable climate besides the extensive cultivation for root purpose. Although, seed production is done on very small scale and seed yield as well as quality is also low making this venture un-economic to the farmers. Reason being non–availability of standardized seed production technology of European carrots. Presently, seed produced in Kashmir valley, Kullu valley and Kalpa (Himachal Pradesh) could not meet the demand of whole country. Hence, the seed of European carrots is being imported in India and we have to pay foreign exchange in lieu of seed import. Around 50 % of the world's carrot seed is produced in New Zealand [3]. Therefore, present studies are contemplated to maximize the seed yield of European carrots in the region with the objective of producing high quality seed of open pollinated varieties of European carrots under Ladakh conditions. This is the first and sole attempt on seed production aspect of European carrots in Ladakh which will prove

to be a step forward for economic upliftment of the farmers. Moreover, quality of seed would be much better due to the fact that there is no or negligible rain fall during seed maturity.

2. MATERIALS AND METHODS

Present investigations were conducted at Stakna Farm of the SKUAST-K High Mountain Arid Agriculture Research Institute, Leh which is situated at 3319 m above mean sea level with latitude $33^0$58.551' NS and longitude $77^0$41.995' EW. Climate of the area is typically dry temperate (Fig 1).

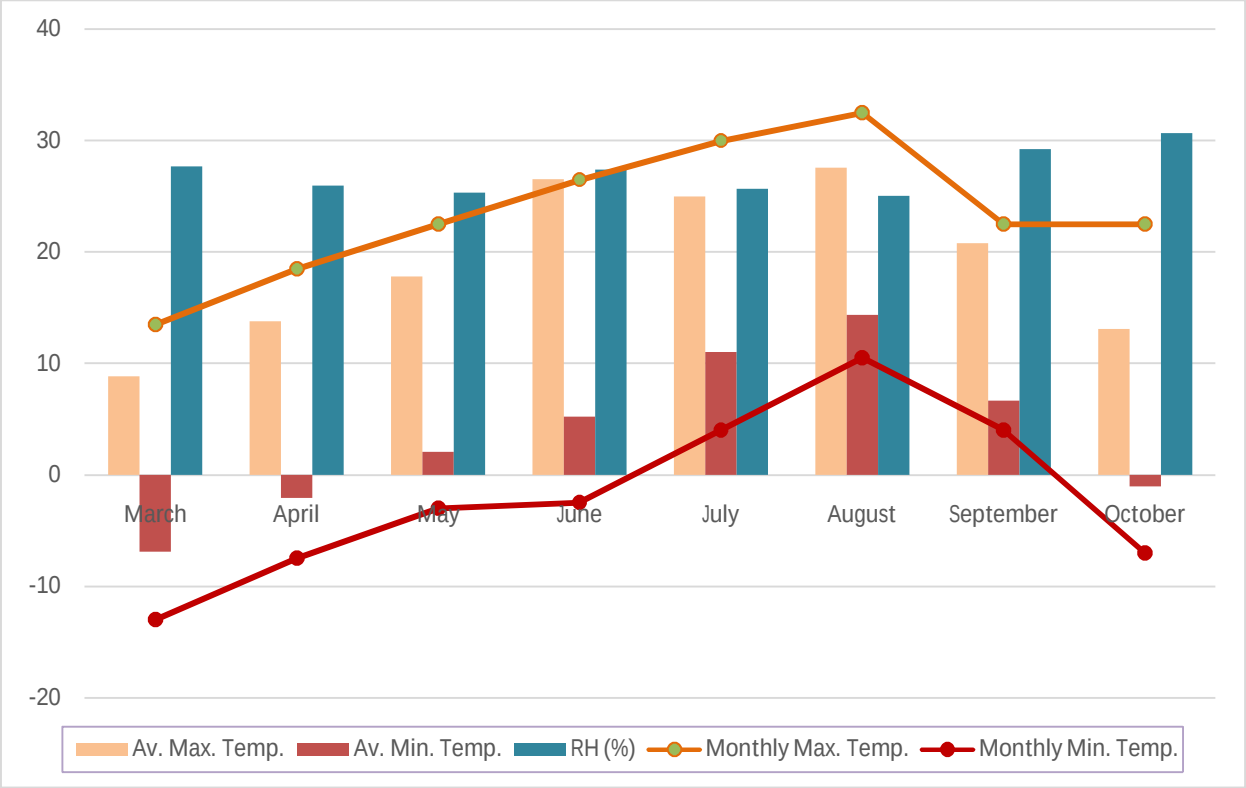

Fig.1: Weather pararameters of experimental area

Root crop of carrot was raised during the crop season i.e. from first week of June to last week of October. Two varieties of carrot viz. Early Nantes and Pusa Yamdagni were taken for seed production.In Ladakh, winters are severe, summer are mild and relative humidity is low during seed maturation. Seed to seed method is not preferred in cold arids as there is no root selection thereby affecting seed quality [4].Disease free and true to the types roots were taken. Two third top of roots was removed keeping 1/3rd portion. These steckling of were stored in the

under ground pits to meet the vernalization requirement in the last week of October. Seed production of temperate carrot requires low temperature and is possible in hills only where their vernalization requirement is met [4].While storing the roots, true to the type roots of the varieties were selected. As the European carrots are biennial for seed production, the seed crop was raised in the next season. Performance of root crop is given in Table 1.

Table 1. Performance of root crop

Particulars	Early Nantes			Pusa Yamdagni		
	Net root weight (g)	Root length (cm)	Root diameter (mm)	Net root weight (g)	Root length (cm)	Root diameter (mm)
Mean	81.5	12.42	32.73	79.1	12.54	34.38
Range	32.0-128.0	11.0-14.5	20.85-38.79	38.8-136.2	10.5-15.0	25.32-46.61
CV(%)	35.22	8.02	17.56	37.68	11.33	18.10

After the completion of the vernalization phase, the carrot starts to initiate floral development [5].In last week of March, 2013, stecklings of these two varieties were taken out from the pits and categorized in four diameter group on the basis of root diameter. After that, these stecklings were replanted in the field after making the hole with crowbar at a spacing of 45x30 cm at two different dates.

Soon after replanting, roots were irrigated with watering can for proper establishment. Material was planted in the split split plot design with three replications.Hence, treatments included two dates of replant (D1: 29 March; D2: 28 April), four diameter groups (G1 :<20mm; G2: 20-25mm; G3: 25-30mm; G4:>30mm) and two varieties (V1: Pusa Yamdagni; V2: Early Nantes) and their combinations to observe main plot, subplot, sub-sub plot and interaction effects, respectively on set of characters. Data were recorded on 6 randomly selected plants for replant survival (%), plant height (cm), days to flowering, days to seed maturity and seed yield per ha (Q) and analysed as per Snedcor and Cochran [6].

3. RESULTS AND DISCUSSION

Performance of European carrots during seed production is appended in Table 2. Growth and development, and physiological activities beginning from seed germination to harvest influence carrot seed yield [7].Date of replant of stecklings significantly influenced the days to flowering and days to seed maturity in European carrots. Diameter group of stecklingsaffected seed yield in

addition to days to flowering and days to seed maturity. However, varieties have significant effect on all the characters under study.

Date of replant x Diameter group interaction could not affect the characters significantly; whereas Date of replant x Variety interaction affected plant height and seed yield significantly. Seed yield was significantly influenced by Diameter group x Variety interaction; whereas three factor interaction of Date of replant x Diameter group x Variety had significant effecton days to flowering and seed yield.

First date of replant (D1) exhibited better effect on replant survival and seed yield but it could not significantly influence both these characters. Results are in conformity with Mengistu and Yamoah [8] who reported decline in seed yield progressively as sowing was delayed. Decline in seed quality in delayed replanting might be due to fact the less season become available to the crop for proper growth and seed production.

Days to flowering and days to seed maturity were statistically lesser in second date of steckling replant (D2). It is clear-cut indication that lower temperature prevailing during first date of steckling replant in Leh conditions (Fig.1) allowed slow growth which ultimately took significantly more time for flowering and hence took more time for the seed maturity.The period of vegetation and flowering of carrot usually is very long [9]. This finding agrees with the reports of Roberts et al. [10] who stated that if cold temperatures are experienced early in growth stages, flowering of most biennial vegetable species is increased.

Diameter group of stecklings (G4) exhibited significantly shortest time to flower (78.74 days) and seed maturity (165.40 days) in European carrot seed crop. Same Diameter group produced statistically highest seed yield (16.47 Q/ha) over all the other diameter groups except Diameter group (G3). It means that diameter group should be selected more than 25 mm to get good seed yield potential. The results depicted that seed yield increased with the increase insteckling size which are in line with the findings of Ashutoshet.al. [11]. These results are also in agreement withParadisi and Montanari [12] and Digole and Shinde [13]who reported that seed yield increased significantly with increasing root diameter and Verma et al.[14]who reported stecklings from large sized roots produce higher seed yields. Similarly, large sized roots recorded the maximum plant height and highest seed yield by Ashutoshet al. [11] in consonance with the Ipresent findings. The increase in seed yield depicted from the resultsmight be due to difference in size of stecklings. Large steckling sizehas more accumulated food as compared to small

steckling size whichaffects morphological characteristics of carrot like number of leaves,size of leaves, production of branches etc. which ultimately leads tomore seed yield. Similar findings were reported by Hamid et al.[15] in radish, Ashutoshet al.[11] in radish, Hemayati et al.[16] in sugar beet, Dev [17]and lyas et al. [18] in carrot.However, Amjad et al. [19] reported that seed yield per plant was not influenced by the mother root size.

Superiority of V2 i.e. Early Nantes over V1 i.e. Pusa Yamdagni for all the characters under study clearly demonstrates that it is economically better to go for seed production of variety Early Nantes besides good root crop potential.

Date of replant (D2) x Diameter group (G4) interaction produced better but non-significant replant survival, plant height, days to flowering and days to seed maturity. Despite the better replant survival plant height, days to flowering and days to seed maturity; this combination could not transform into better seed production.

Date of replant (D2) x Variety (V2) produced statistically better plant height which was followed by Date of replant (D1) x Variety (V1) whereas seed yield was observed statistically at par in Date of replant (D1) x Variety (V2) and Date of replant (D2) x Variety (V2). This trend confirms that variety has pronounced effect on seed yield of European carrots.

Steckling diameter group (G4) x Variety (V2) produced statistically highest seed yield followed by Steckling diameter group (G3) x Variety (V2) which provide confirmatory evidence of better seed yield by Diameter groups G3 and G4 with Variety V2 i.e. Early Nantes.

Date of replant (D1) x Diameter group (G4) x Variety (V2) generated highest seed yield over the other three factor combinations except Date of replant (D2) x Diameter group (G4) x Variety (V2). Rest of characters showed non-significant differences.Warmer temperature (30 °C) reduced the receptive period of stigma, which can negatively affect the fertilization process [20]. Furthermore, Broussard et al. [21] suggested that increasing temperatures may have an impact on carrot flower attributes that attract pollinators, including nectar concentration and volatile emission. Pollinators' subsequent foraging behavior may be impacted as a result of this. Elballa and Cantliffe [22] also reported that exposing carrot seed crops at anthesis or before seed development to a warm temperature (33/28 °C) could adversely affect the seed yield and seed quality of carrots.In the experimental area, temperature (Fig.1) remained below 30^{o}C during flowering, thereby increasing the seed yield potential of the crop.As evident from present

investigations, there is potential of disease free and quality seed due to arid conditions (low relative humidity and scanty rains) of Ladakh region (Fig. 1) prevailing at seed maturity time.

4. CONCLUSIONS

It may be concluded that steckling replanting of variety Early Nantes in April with root diameter more than 25 mm would give highest seed yield in Leh conditions and is recommended for whole Ladakh region. Beside better seed yield, seeds were vigorous and diseases free because of cold arid climate of the region. Ladakh region can be a seed production hub of European carrots and requirement of seed import to India can be minimized if potential is tapped judiciously.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Table 2. Performance of European carrots for various traits during seed production

Factor(s)	Replant survival (%)	Plant height (cm)	Days to flowering	Days to seed maturity	Seed yield (qtl./ha)
D1	85.25	127.42	94.68	179.92	14.44
D2	88.38	130.94	70.32	153.29	12.06
CD (D)	**NS**	**NS**	**3.50**	**3.10**	**NS**
G1	81.33	124.00	85.90	168.92	9.62
G2	87.00	126.92	85.24	168.33	11.05
G3	85.83	131.38	80.12	164.67	15.43
G4	93.08	134.42	78.74	164.50	16.89
CD (G)	**NS**	**NS**	**3.84**	**1.94**	**3.35**
V1	82.08	110.29	87.08	167.50	10.02
V2	91.54	148.06	77.92	165.71	16.47
CD (V)	**7.74**	**5.05**	**2.96**	**1.09**	**1.82**
D1xG1	83.50	124.50	97.79	181.67	11.71
D1xG2	86.00	123.33	95.88	181.33	9.92
D1xG3	83.67	129.17	91.72	178.00	18.50
D1xG4	87.83	132.67	93.35	178.67	17.61
D2xG1	79.17	123.50	74.00	156.17	7.53
D2xG2	88.00	130.50	74.61	155.33	12.18
D2xG3	88.00	133.58	68.53	151.33	12.35
D2xG4	98.33	136.17	54.13	150.33	16.16
CD (DxG)	**NS**	**NS**	**NS**	**NS**	**NS**
D1xV1	82.75	114.17	92.33	181.17	12.13
D1xV2	87.75	140.67	79.46	178.67	16.74
D2xV1	81.42	106.42	91.53	153.83	7.90
D2xV2	95.33	155.46	78.96	152.75	16.21
CD (DxV)	**NS**	**7.14**	**NS**	**NS**	**2.57**
G1xV1	78.33	102.00	92.33	169.50	7.57
G1xV2	84.33	146.00	79.46	168.33	11.67
G2xV1	79.50	108.00	91.53	169.17	9.71
G2xV2	94.50	145.83	78.96	167.50	12.39
G3xV1	80.50	114.67	83.63	166.33	12.04
G3xV2	91.17	148.08	76.61	163.00	18.81
G4xV1	90.00	116.50	80.83	165.00	10.74
G4xV2	96.17	152.33	76.64	164.00	23.03
CD (GxV)	**NS**	**NS**	**NS**	**NS**	**3.64**
D1xG1xV1	82.67	109.33	105.33	182.33	9.96
D1xG1xV2	84.33	139.67	90.25	181.00	13.46
D1xG2xV1	80.67	107.33	104.33	183.00	9.55

D1xG2xV2	91.33	139.33	87.42	179.67	10.29
D1xG3xV1	84.33	120.00	91.25	179.67	18.16
D1xG3xV2	83.00	138.33	92.17	176.33	18.85
D1xG4xV1	83.33	120.00	94.33	179.67	10.86
D1xG4xV2	92.33	145.33	92.36	177.67	24.36
D2xG1xV1	74.00	94.67	79.33	156.67	5.18
D2xG1xV2	84.33	152.33	68.67	155.67	9.88
D2xG2xV1	78.33	108.67	78.72	155.33	9.88
D2xG2xV2	97.67	152.33	70.50	155.33	14.49
D2xG3xV1	76.67	109.33	76.00	153.00	5.93
D2xG3xV2	99.33	157.83	61.05	149.67	18.77
D2xG4xV1	96.67	113.33	67.33	150.33	10.62
D2xG4xV2	100	159.33	60.92	150.33	21.71
CD (DxGxV)	**NS**	**NS**	**8.39**	**NS**	**5.15**

D: Date of replanting; D1: 29 March; D2: 28 April

G: Diameter group; G1 :<20mm; G2: 20-25mm; G3: 25-30mm;G4:>30mm

V: Variety; V1: Pusa Yamdagni; V2: Early Nantes