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STUDIES ON ASIATIC CARROT CULTIVARS FOR THEIR QUALITY AND YIELD UNDER SUB-TROPICAL PLAIN AREAS OF GUJARAT

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ABSTRACT
An experiment was conducted to evaluate the performance of twelve carrot genotypes at Seed Spices Research Station, S.D. Agricultural University, Jagudan and Agriculture Research Station, Ladol during the period from 2010 to 2012. The results showed the supremacy of the genotype Gujarat Dantiwada Carrot-1 (JDNCT 22) over the other genotypes in root yield 44.8 t ha^{-1} over both the checks, *viz.,* Pusa rudhira (39.2 t ha^{-1}) and Pusa ashita (30.8 t ha^{-1}). The yield potential of this variety is 59 t ha^{-1}. The roots are red, fleshy and medium long in length, 22 cm (19.2 to 25.2), average root weight, 91.8 g (66.4 to 112.7), root girth, 10.8cm (9.5 to 12.3) and plant height of 61cm (54.0 to 72.7). The bio-chemical analysis revealed that GDC- 1 had high total soluble sugar and high moisture content. It is also rich in β-Carotene than Pusa ashita. On the basis of root and quality performance, GDC-1 is recommended as high yielding best carrot Asiatic variety under sub-tropical plain area of Gujarat.

INTRODUCTION

Carrot (*Daucus carota* L.), a *rabi* crop belongs to the family Apiaceae having chromosomes 2n = 18 and known as "Gajar" in vernacular language. It is an important vegetable crop grown in tropical and sub-tropical regions all over the world. The major carrot growing states in India are Punjab, Uttar Pradesh, Karnataka, Tamil Nadu and Andhra Pradesh. In India, the total cultivated area under carrot is 71.22 thousand hectares with an annual production of 11.36 lakh tonnes and productivity is 16t ha^{-1} (Anon., 2015). In Gujarat, its area, production and productivity are estimated to be 10000 ha, 2 lakh tonnes and 20t ha^{-1}, respectively. It is usually orange, purple, red, white or yellow in color, with a crisp texture and a rich source of β-carotene and contains other vitamins, like thiamine, riboflavin, vitamin B-complex and minerals (Walde *et al.,* 1992). Carrot varieties are dividing into two groups *viz.,* Asiatic or tropical types and European or temperate types is orange color due to the presence of β-carotene, a precursor of vitamin 'A'. Asiatic carrot is red in color due to the presence of the pigment lycopene and beta carotene (Prajapati *et al.,* 2014). This is highly nutritious cool season root crop. It ranked third among the succulent vegetables in world production (Anand *et al*., 2016). Among succulent vegetable crops, carrot ranks third in world production (Ahmed *et al*., 2014). Lycopene has been shown to reduce the risk of cancer. Carrot is used as a vegetable for soups, stows, curries and pies; grated roots are for salad. Tender roots are used for making pickles and halwa. In general, carrots are important for healthy eyes, skin, hair, growth and immune systems. They can lower cholesterol, prevent heart attacks and reduce the risk of certain types of cancers. Carrot juice is very popular and is the main source of carotene and is also used as coloring buffer in food preparation. Carrot leaves (tops) are also used in many countries as a source for extraction of leaf proteins, fodder and the preparation of poultry feed. Purple and black carrots are used for the preparation of beverage called 'Kanjal' which is very good appetizer. More productive cultivars and hybrids of crops such as carrot with a higher nutritional content need to be developed to ensure global access to a secure, balanced diet (Dias, 2010). Farmers are using their own seed material, it has early bolting and xylem/ woody tissue (self core) is greater and also it is of heterozygous in nature and not stable being a cross pollinated crop. Moreover, the seeds of improved carrot cultivars have not been easily available to farmers to grow carrots, unless imported from others. Therefore, a study was initiated to assess the potential of some Asiatic carrot cultivars for their ability to produce high quality carrots as well as yield under sub-tropical plain areas of Gujarat.

MATERIALS AND METHODS

Thirty eight germplasm were collected from carrot growing areas around Patan and Mehsana districts of Gujarat and evaluated on the basis of yield with shape and size, quality traits after purifying lines at root level and with the root-to-seed method of selection have done to select uniform plant type at plant growth period for many root characteristics (www.seedalliance.org, 2010). After uniformity of all genotypes they were tested for its yield performance and

ancillary characters in preliminary and small scale trials during *Rabi* 2008 and 2009, respectively at Jagudan. Planting was carried out during the month of November and were harvested for root yield in about 96 days after planting (during January). Among these, twelve high yielding lines *viz.*, JDNCT-11, JDNCT-13, JDNCT-14, JDNCT-18, JDNCT-22, JDNCT-32, JDNCT-34, JDNCT-35, JDNCT-36, JDNCT-37 including two checks *viz.*, Pusa rudhira and Pusa ashita were found promising and these entries were tested in large scale varietal trial in a randomized block design with three replications at Seed Spices Research Station, S. D. Agricultural University, Jagudan and Agricultural Research Station, S. D. Agricultural University, Ladol during 2010 to 2012. The plot size was 1.8m × 3.0m with row to row spacing 30cm and 10cm between two plants. The recommended package of practices was followed during the course of investigation. Five plants were randomly selected in each genotype and replication. The quantitative characters *viz.*, plant height (cm), no. of leaves plant^{-1}, average leaf weight (g), petiole length (cm), leaf length (cm), average root weight (g), root girth (cm), root length (cm), days to first harvest, days to 50 % bolting and moisture per cent were recorded. The bio-chemical parameters studies have also been determined. The mean values of various characters of each genotype and each replication were subjected to analyze as per the standard procedure of randomized block design of Panse and Sukhatme (1967). The critical differences were calculated at five per cent level. β-carotene content was determined by using the column chromatography as per the method given by Raghuramulu *et al.* (2001)**.** Total soluble sugar was estimated by phenol-sulphuric acid method as described by Dubois *et al.* (1956).

$WC = 100 \times (M_1-M_2)/M_1$ where,

WC = Water content (%)

M_1 = Mass of sample before drying (g)

M_2 = Mass of sample after drying (g)

The water content (WC) of carrot was determined using the equation as per method of Upadhyay *et al.* (2008). The sample was also dried under the sun than drying in hot oven, only temperature was kept varied from 60ºto 80º C. During tray drying, moisture content was recorded at a 10 minutes interval for first hour and later at 30 minutes interval until the sample attained equilibrium with the drying environment and no reduction in the mass of the sample was recorded.

RESULTS AND DISCUSSION

Among twelve genotypes, variety Gujarat Dantiwada Carrot-1 (JDNCT-22) showed significantly superior for their root yield performance along with two checks *viz.***,** Pusa rudhira and Pusa ashita in six large scale varietal trials at two different locations *viz.*, Jagudan and Ladol, on an average Gujarat Dantiwada Carrot-1 (JDNCT-22) produced 44.8 t ha^{-1} root yield against 39.2 and 30.8 t ha^{-1} of Pusa rudhira and Pusa ashita check variety. The Gujarat Dantiwada Carrot-1 (JDNCT-22) genotype significantly out yielded both the checks *viz.***,** Pusa rudhira and Pusa ashita in 6/6 tests at both the locations and produced 14.3 and 45.5 per cent higher root yield, respectively, indicating its superiority in yield over the years and locations. The yield potential of this variety has 59.0 t ha^{-1} (Table 1). The roots of Gujarat Dantiwada Carrot-1 were found tender and fleshy with medium in size, cylindrical shape and light red in color. It possesses more root weight, length and medium girth (Table 2 and 3). The analysis of nutritional and bio-chemical properties revealed that Gujarat Dantiwada

Table 1: Comparative root yield performance of GDC-1 at individual and mean over locations

Location	*Name of experiment and year*	*Root yield* (t ha^{-1}) GDC-1 (JDNCT-22)	Pusa rudhira	*% increase over* Pusa ashita	Pusa rudhira	Pusa ashita	*C.D. (5 %)*	*C.V.%*
Jagudan	*LSVT-2010*	41.5* (2)	37.9 (3)	34.2 (7)	9.4	10.8	5.7	9.6
	LSVT-2011	39.4* (1)	36.8 (5)	32.8 (8)	7.1	20.1	7.0	12.4
	LSVT-2012	59.0* (2)	54.4 (4)	38.0 (5)	8.4	43.3	5.5	7.8
	Mean (3)	46.6	43.0	35.0	8.4	33.1		
Ladol	*LSVT -2010*	25.9* +(1)	16.1 (6)	14.2 (9)	60.7	13.5	2.7	8.7
	LSVT-2011	55.6* (1)	48.1 (5)	41.4 (9)	15.6	34.3	8.0	10.3
	LSVT-2012	47.3* (1)	42.0 (4)	24.4 (11)	12.7	72.2	6.5	11.1
	Mean (3)	42.9	35.4	26.7	21.2	60.7		
Over all Mean (6)	44.8	39.2	30.8	14.3	45.5			
Superiority over check			6/6	6/6				

Note: * and + indicates significantly superiority over Pusa ashita and Pusa rudhira, respectively; () indicates the rank of genotype in their respective trials.

Table 2: Root yield attributing characters

Characters	GDC-1	Pusa rudhira	Pusa ashita
Plant height (cm)	61 (54.0-72.7)	61 (54.2-70.6)	53 (47.1-55.5)
No. of leaves plant^{-1}	8.0 (6.6-9.0)	8.1 (7.6 - 8.6)	8.6 (7.8 - 8.9)
Root length (cm)	22.0 (19.2-25.2)	19.9 (15.9 -23.7)	18.6 (15.7-24.6)
Root girth (cm)	10.8 (9.5-12.3)	11.1 (9.8 -13.2)	10.7 (8.9 -13.1)
Average Root weight(g)	91.8 (66.4-112.7)	91.2(69.4 -106.7)	88.7(68.0-104.4)
Average Leaf weight (g)	92 (51.0-164.0)	87 (60.0 -153.6)	82 (64.8 -117.6)
Petiole length (cm)	22.4 (20.8-23.9)	23.2 (22.2 - 24.2)	18.3 (17.0 -19.6)
Days to 50 % bolting	108	104	112
Days to first harvest	96	97	105

Table 3: Morphological Descriptors of GDC-1

Descriptors	GDC-1	Pusa rudhira	Pusa ashita
Leaf colour	Green	Dark green	Purple
Root colour	Red	Red	Purple
Root shape	Cylindrical	Cylindrical	Cylindrical
Petiole cavity	Broad & Shallow	Narrow & Deep	Broad & Deep
Core size	Medium	Large	Absent
Root flavour	Sweet	Sweet	Turpentine
Root hair	Present	Present	Absent

Table 4: Bio-chemical analysis

Entries	Moisture (%)	Total Soluble Sugar (%)	β-Carotene (μg g^{-1})
GDC-1	90.57	7.37	40.00
Pusa rudhira	89.71	6.39	42.58
Pusa ashita	89.00	6.58	39.06

Table 5: **Pest and diseases reactions**

Pest/ Diseases	Year reactions	
	2008-09 to 2012-13	There was no occurrence of diseases & pest during the course of investigation

Carrot-1 (JDNCT-22) has high total sugar and high moisture per cent hence; it is most suitable for juice purpose. It is rich also in β-Carotene (40 µg g^{-1}) and remained at par with Pusa ashita (39.06%) (Table 4), which are globally important providing important nutritional compounds (including pro-vitamin A) through their carotenoid content whilst adding flavor and texture to many diets across the world (Heinonen, 1990). The roots of Gujarat Dantiwada Carrot-1 are more acceptable owing to its tenderness, better shape and size, red colour with more palatable and good luster. The genotype Gujarat Dantiwada Carrot-1 (JDNCT-22) has an erect plant type with an average plant height of 61 cm (54.0 to 72.7). The roots are red, fleshy and medium long in length, 22 cm (19.2 to 25.2), average root weight 91.8 g (66.4 to 112.7), root girth, 10.8 cm (9.5 to 12.3) (Table 2). Similarly, the research findings are in accordance with Simon and Wolf (1989) that average root weight, average root length, average root girth are important criteria for selection and varied performance of cultivars with regards to genotype, location and season. It matures for first harvest in 96 days after sowing.

Morphologically, the root colour of Gujarat Dantiwada Carrot-1 is red, root forking is absence, core size is medium and edible due to merged to root with red color, root flavour is sweet and root shape is cylindrical type (Table 3).

Bio-chemical analysis component *viz*., Moisture content (%), β-carotene (μg g-1) and total sugar (%) were recorded in two varieties *viz*., GDC-1 and Pusa ashita revealed that the variety Gujarat Dantiwada Carrot-1 (90.57 %, 40.00 µg g^{-1}, 7.37 %) were found more moisture content, β-carotene and total sugar than check, Pusa ashita (89.00 %, 39.06 µg g^{-1}, 6.58 %), respectively. β-carotene and total sugar (%) were found more, so it is more sweet and red than Pusa ashita. Similarly, JDNCT-22 (GDC-1) genotype found higher in total soluble sugar (7.11%) and Moisture content (89.5 %) than Pusa rudhira recorded by Prajapati *et al*.(2014). Bohm *et al*. (1999) reported juice yield in carrot as only 60-70 %, whereas, in Gujarat Dantiwada Carrot-1 (90.57 %) found 2 % higher moisture content than Pusa ashita, so, it is better for juice purpose (Table 4).

During the course of investigation, no incidence of any pest or disease was occurred during the period of testing in any of the test entries (Table 5). The study indicated that Gujarat Dantiwada Carrot-1 considered for higher root yield as well as better root quality, no root forking habit, Gujarat Dantiwada Carrot-1 (JDNCT-22) variety, due to its attractive long red roots, red colored core, uniformity in shape and size, found higher sugar is 7.37 % and β-carotene 40 µg g^{-1}.

The variety, Gujarat Dantiwada Carrot-1 was released in 45th State Seed-Sub Committee of Gujarat (SSSC, 2014) in the vegetable growing areas of Gujarat to make the crop more profitable. It has been assigned national identity number (IC No.596514) by Division of Germplasm Conservation, National Bureau of Plant Genetic Resources, ICAR, Pusa Campus, New Delhi (2013).

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