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Research Note

Genetic variability studies in carrot (*Daucus carota* L.) under low hill regions of Himachal Pradesh

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Abstract
The purpose of this study was to determine the nature, extent and magnitude of genetic variability, as well as estimate of the coefficient of variability, heritability and genetic advance as a percentage of the mean. During the *rabi*, 2020-21, twenty-three diverse genotypes of carrot were laid out in RCBD design at the Experimental Farm of the Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur, Himachal Pradesh. Observations were recorded on sixteen economic traits. For all traits, significant differences were found among all genotypes. PCV was greater than the corresponding GCV for all the traits, indicating that the environment has a significant impact on character expression. GCV, heritability and genetic advance as per cent of mean were high for root: shoot ratio, plant height at harvest, carotene content and total yield per plot, indicating that selection for these traits would be beneficial in improving carrot yield.

Keywords: Carrot, *Daucus carota* L., Variability, Heritability, Genetic Advance, Genetic gain

Carrot (*Daucus carota* L.) is one of the most popular root vegetable crops, extensively cultivated in tropical and temperate countries of the world, for its fleshy edible roots. It is a cool-season crop belongs to the family Apiaceae with the diploid chromosome number 2n=2x=18. Carrots are native to Southwestern Asia, especially Afghanistan (Banga, 1976) and are an important root crop cultivated in India. It is classified into two groups: Asiatic (tropical) and European (temperate) types. Because of their delicious taste, flavour and nutritional value, carrots hold a prominent role in the market. The tender roots of carrot are used to make gajarhalwa, soups, pickles, sweetmeat and pies. The roots of black carrots are often used to make a fermented product called Kanji (an appetizing drink). Carrot is known for its β-carotene and carotenoids content. It is an excellent source of vitamin A and also contains a considerable quantity of thiamine and riboflavin (Salunkhe and Kadam, 1998). Carrot roots are used to cure ulcers, burns, scalds and jaundice (Rana, 2008). Wider diversity occurs with respect to pigmentation in wild and cultivated carrot roots (Nicolle *et al*., 2004; Surles *et al*., 2004). These pigments have powerful antioxidant properties which exert a variety of health-related benefits (Ross and Kasum, 2002). Despite its economic and nutritional value, India has done little research on varietal production and improvement. As a result, there is a need to investigate the variability of different horticultural traits in carrot genotypes in order to identify superior varieties through introduction, selection or hybridization. Before the enhancement of any breeding or crop improvement programme, it is essential to analyse variability present in the base population or genetic material utilized. The more variation in a population, the more opportunities for effective selection of preferred types (Vavilov, 1951). Phenotypic and genotypic coefficients of variation is useful in detecting amounts of variability

present in the base population. Heritability refers to the proportion of phenotypic variation that is passed down from parent to progeny. In predicting genetic gain under selection, heritability estimates combined with genetic advances are more useful than heritability estimates alone (Johnson *et al*., 1955). Keeping in view the above points, the current study was carried out to assess the nature, extent and magnitude of genetic variability, estimates of the coefficient of variability, heritability and genetic advance as a percentage of the mean.

The present study was carried out during the *rabi*, 2020-2021 at Experimental Farm of Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur, Himachal Pradesh, which is located at an altitude of 650 meters above mean sea level, lying between latitude and longitude of 31˚41'47.6" North and 72˚28'6.3" East, respectively under low hill zone of Himachal Pradesh. Twenty-three different genotypes of carrots were collected from various locations and were evaluated along with one standard check (**Table 1**). Seeds were sown at 30 × 10 cm inter and intra row spacing in mid of September in a plot size of 1.2 × 1 m^2 in a randomized complete block design with three replications. To ensure healthy crop cultural operations like thinning, hoeing, weeding, earthing up, timely irrigations and plant protection measures were carried out as per the package of practices as and when required during the entire course of research. Observations were recorded on sixteen economic characters *viz*., days to 50% germination, plant height (cm), leaf length (cm), the number of leaves per plant, days to harvest, crown diameter (cm), core diameter (cm), root length (cm), root diameter (cm), root weight (g), root:shoot ratio, flesh thickness (cm), total yield per plot (kg), total soluble solids (°B), dry matter content (%) and dry samples were used to calculate carotene content (mg/100 g) as the procedure described by AOAC (1970). The mean values of various parameters were subjected to analysis of variance as described by Gomez and Gomez (1984). The phenotypic and genotypic coefficient of variation (PCV and GCV) were estimated as per Burton and De Vane (1953). Heritability in the broad sense and genetic advance (as a percentage of mean) were calculated according to Allard (1960) and Johnson *et al*. (1955), respectively.

Table 1. List of genotypes of Carrot along with their source

S. No.	Genotypes	Source
1.	Kashi Krishna	IIVR, Varanasi
2.	Pusa Yamdagini* (check)	IARI Regional Station, Katrain
3.	PC-161	PAU, Ludhiana
4.	Nantes	IARI Regional Station, Katrain
5.	Kashi Arun	IIVR, Varanasi
6.	Hisar Gairic	HAU, Hissar
7.	Pusa Nayanjyoti	IARI Regional Station, Katrain
8.	Pusa Rudhira	IARI, New Delhi
9.	Laxmangarh Selection	National Innovation Foundation
10.	Durgapur-4-Red	National Innovation Foundation
11.	CA-COHFNERI-3	Department of Vegetable Science, COH&F Neri, Hamirpur
12.	Punjab Black Beauty	PAU, Ludhiana
13.	CA-COHFNERI-2	Department of Vegetable Science, COH&F Neri, Hamirpur
14.	CA-COHFNERI-1	Department of Vegetable Science, COH&F Neri, Hamirpur
15.	Madhuban	National Innovation Foundation
16.	VRCAR-198	IIVR, Varanasi
17.	VRCAR-96	IIVR, Varanasi
18.	VRCAR-160	IIVR, Varanasi
19.	VRCAR 171-1	IIVR, Varanasi
20.	VRCAR-85	IIVR, Varanasi
21.	VRCAR-109	IIVR, Varanasi
22.	VRCAR-184	IIVR, Varanasi
23.	Pusa Vrishti	IARI, New Delhi

PAU- Punjab Agricultural University, HAU- Hisar Agricultural University, IARI- Indian Agricultural Research Institute, COH&F- College of Horticulture and Forestry, IIVR -Indian Institute of Vegetable Science.

Performance of carrot genotypes for different morphological traits based on visual observation is presented in (**Table 2 & Fig.1**). A wide range of variation was observed for plant height (40.50 to 111.47 cm) and root weight (50.43-125.20 g). The magnitude of genetic variability present in the carrot genotypes was assessed in terms of range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance as per cent of mean (**Table 3**). The magnitude of the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits, indicating that the environment has a significant impact on character expression. High magnitude of GCV and PCV were observed for root:shoot ratio followed by plant height, total yield per plot and carotene content indicating the presence of genetic variation among these characters and has plenty of potential for crop improvement through effective selection for these traits. Flesh thickness, root weight, leaf length, core diameter, days to 50% germination, crown diameter and root diameter exhibited moderate magnitude of GCV and PCV showed that a considerable amount of variability was found for these traits and can be used in further crop improvement. The low magnitude of GCV and PCV was observed for total soluble solids, dry matter content and days to harvest indicating that there was a little prospect of improving these characters through direct selection. Root length had a low GCV but a moderate PCV, showing that the expression of these attributes is influenced by soil conditions, growth conditions and the surrounding environment. Genetic variability alone cannot be used to determine heritable variation. Burton and De Vane (1953) suggested that GCV along with heritability gives a clearer picture about the efficiency of selection. Heritability is referred as the portion of phenotypic variation which is transmitted from parents to their off springs. High estimates of heritability were recorded for carotene content, dry matter content, crown diameter, total soluble solids, days to harvest, plant height at harvest, root:shoot ratio, days to 50% germination, the number of leaves per plant, and root length. Selection is more beneficial for the improvement of these traits which are having high heritability. Heritability estimates alone might not provide clear predictability of the breeding value. As a result, heritability estimates combined with genetic advances are more useful than heritability estimates alone in predicting genetic gain under selection (Johnson *et al*., 1955).

Table 2. Performance of carrot genotypes for different morphological traits

Genotypes	Root Shape	Root Colour	Self-core Yes/No
Kashi Krishna	Tapering	Purple	Yes
Pusa Yamdagini	Slightly Tapering	Orange	Yes
PC-161	Tapering	Red	Yes
Nantes	Cylindrical	Orange	Yes
Kashi Arun	Tapering	Red	Yes
Hisar Gairic	Tapering	Red	Yes
Pusa Nayanjyoti	Cylindrical	Orange	Yes
Pusa Rudhira	Tapering	Dark Red	Yes
Laxmangarh Selection	Tapering	Red	Yes
Durgapur-4-Red	Tapering	Red	No
CA-COHFNERI-3	Tapering	Red	No
Punjab Black Beauty	Conical	Black	No
CA-COHFNERI-2	Tapering	Red	Yes
CA-COHFNERI-1	Tapering	Red	Yes
Madhuban	Conical	Dark Red	No
VRCAR-198	Tapering	Light Red	No
VRCAR-96	Conical	Red	Yes
VRCAR-160	Tapering	Yellow	Yes
VRCAR 171-1	Conical	Light Red	No
VRCAR-85	Tapering	Orange	Yes
VRCAR-109	Tapering	Red	Yes
VRCAR-184	Tapering	Red	Yes
Pusa Vrishti	Conical	Red	Yes

Fig. 1. Genetic variability present in carrot genotypes

Table 3. Estimates of range, phenotypic and genotypic coefficients of variation, heritability and genetic advance as % of mean

S. No.	Characters	Mean	Range		Coefficient of variation (%)		Heritability (%)	Genetic Advance as % of mean
			Minimum	Maximum	Genotypic	Phenotypic		
1	Days to 50% germination	9.59	7.00	14.00	22.04	24.00	84.34	41.69
2	Plant height at harvest (cm)	79.56	40.50	111.47	61.99	64.49	92.38	122.73
3	Leaf length (cm)	57.60	24.73	84.03	22.25	25.29	77.40	40.32
4	Number of leaves per plant	7.35	5.03	12.67	22.56	24.70	83.40	42.43
5	Days to root harvest	90.56	85.00	101.67	3.73	3.82	95.56	7.52
6	Crown diameter(cm)	3.22	2.08	4.30	19.06	19.12	99.35	39.13
7	Core diameter(cm)	1.61	1.02	2.11	15.39	24.02	41.06	20.31
8	Root length(cm)	21.96	15.77	27.43	14.10	15.76	80.13	26.01
9	Root diameter(cm)	3.43	2.32	4.42	15.38	18.02	72.90	27.06
10	Root weight (g)	85.74	50.43	125.20	18.57	26.85	47.85	26.46
11	Root : shoot ratio	1.75	0.92	4.14	87.02	93.87	85.94	166.18
12	Flesh thickness (cm)	1.82	0.97	2.68	22.00	27.00	66.40	36.93
13	TSS (ºB)	5.52	4.03	7.00	13.80	13.90	98.55	28.22
14	Dry matter content (%)	11.07	9.23	14.23	12.22	12.23	99.77	25.13
15	Carotene content (mg/100 g) of dry fruits	15.24	2.69	26.61	51.39	51.40	99.94	105.82
16	Total yield per plot (kg)	3.12	0.40	6.00	52.17	58.69	79.01	95.53

High genetic advance as per cent of mean (genetic gain) was recorded for the trait root:shoot ratio, plant height at harvest, carotene content and total yield per plot. This indicates the preponderance of additive genes and highlighted the importance of selection for the improvement of these attributes. Low genetic advance as per cent of mean was reported for core diameter and days to harvest which indicates the preponderance of non-additive gene action and selection based on these parameters found not effective.

In the present investigation, a wide range of variations was observed for almost all the characters. Characters *viz.,* root:shoot ratio, plant height at harvest, carotene content and total yield per plot showed higher values for GCV, heritability and genetic advance as per cent of mean indicating that the selection for these traits would be effective for bringing improvement in carrot yield.

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