

# Genetic variability, heritability and genetic advance for quality traits in carrot (*Daucus carota* L.)

Paramjeet Kaur, D.S. Cheema and Neena Chawla

Department of Vegetable Crops, Punjab Agricultural University, Ludhiana-141004,

E-mail: [candycheema@satyam.net.in](mailto:candycheema@satyam.net.in)

## Abstract

Genetic variability, heritability and genetic advance for different quality characters were studied in 38 genotypes of carrot. The study indicated existence of considerable amount of genetic variability for all the characters studied. The carotene content exhibited highest value of genotypic and phenotypic coefficient of variation, heritability (broad sense) and genetic advance as per cent of mean. The results indicate that this characters can be effectively improved through selection.

**Key words:** Carrot, *Daucus carota*, genetic advance, heritability, variability, quality, coefficient of variation.

## Introduction

A wide range of diversity for quality traits like carotenoids, T.S.S., total sugars etc. has been reported in carrot germplasm (Saimbhi and Sukhijia, 1984; Kalloo *et al.*, 1993; Kowalska *et al.*, 2001; Bhatia *et al.*, 2002). A large number of collections are available in carrot but most of them lack in one or other qualitative or quantitative characters. Thus, the selection of ideal genotype can only be made by making assessment of various characters and the exploration of genetic variability in the available germplasm is a pre-requisite in a breeding programme for effective selection of superior genotype. The partitioning of total variability into heritable and non-heritable components by using suitable design will enable the breeder to know whether the superiority of selection is inherited by the progenies. So, there is an urgent need of information on the nature and magnitude of variation available in the material and part played by environment in expression of different characters.

Therefore, it is desirable to conduct variability studies such as genotypic and phenotypic coefficient of variation (GCV & PCV), heritability and genetic advance on quality traits in thirty eight diverse genotypes of carrot.

## Materials and methods

The present investigation was carried out at the Vegetable Experimental Farm and in the Department of Vegetable Crops, PAU, Ludhiana during the crop seasons of 2002-03 and 2003-04. Experiment was laid out in a randomized complete block design with three replications. The experimental material comprised of 38 Asiatic and European carrot genotypes of diverse geographical origin. Among the these genotypes Nantes, Pusa Yamdagini and Pusa Kesar were European or Temperate type and remaining were Asiatic or Tropical type.

Each accession was sown in one row having 3m length and 45cm apart. The sowing was done manually on ridges. The plants were thinned to maintain plant to plant distance of 7.5 cm, about a fortnight after seedling emergence. The observations were

recorded on ten randomly selected plants per replication for each accession on quality traits at the time of harvest.

Carotene content was determined by the method suggested by A.O.A.C (1966). 2g of fresh carrot root were taken and grounded with 3% acetone in petroleum ether with a pinch of  $\text{Na}_2\text{SO}_4$ . Residue was filtered 2-3 times till the extract was free from trace of yellow colour. The contents were poured in a separatory funnel and acetone was washed with distilled water. The petroleum ether layer was separated out. The final volume was made to 50 ml with petroleum ether and the optical density was read at 452 nm in spectrophotometer along with petroleum ether as blank. The carotene was calculated from the calibration curve prepared using  $\beta$ -carotene. For total sugars dried carrot sample (0.5g) was refluxed in 80% ethanol by heating over a water bath for 2 hr. It was filtered and extraction was repeated twice then extract was clarified using saturated lead acetate solution (5ml), filtered again and excess of lead acetate was removed with sodium oxalate (1-2g). the solution was filtered through Whatman No. 1 filter paper and made to 50 ml using distilled water. 1 ml aliquat from the solution was taken in a test tube and 1 ml of 5 % phenol, followed by 4 ml conc. sulphuric acid were added. The optical density read at 490 nm. A calibration curve was prepared in the same manner using D-glucose in the range 20-100  $\mu\text{g}/\text{ml}$ . T.S.S. was recorded from juice of 10 randomly selected roots from each plot using refractrometer. Juice was extracted from 1 kg carrots using food processor and juice was measured using a graduated cylinder. For dry matter 10 randomly selected roots were washed, topped and peeled and then cut into 3 mm thin pieces. 50g sample was taken and oven dried at  $60 \pm 2^\circ\text{C}$  in hot air oven till constant weight, weighed and dry matter was calculated.

Genotypic and phenotypic coefficient of variation were calculated as per the formula suggested by Burton and Devane (1953). Heritability in broad sense and expected genetic advance were calculated as per the formula given by Allard (1960) and Johnson *et al.* (1955), respectively.

Table 1. Mean *per se* performance of genotypes (pooled over two years, 2002-03 and 2003-04)

Genotypes	T.S.S (%)	Dry matter (%)	Carotene (mg 100g <sup>-1</sup> )	Juice yield (ml kg <sup>-1</sup> )	Total sugars (%)
Alipur Collection	7.90	7.85	6.10	498.83	4.19
Kaparthala Collection	7.68	7.90	5.97	481.83	4.61
Sultanpur Lodi Collection	6.88	7.05	1.04	466.67	4.36
HC-3	7.13	6.90	1.48	497.66	3.97
HC-17	6.31	8.36	1.58	515.83	4.05
HC-18	7.66	7.42	3.56	508.50	3.67
HC-42	7.08	7.37	1.11	513.00	4.28
HC-119	6.71	7.58	1.23	501.00	4.39
HC-155	6.50	7.70	1.43	485.00	4.25
HC-191	6.91	7.77	0.90	477.33	3.99
HC-195	6.13	8.24	1.71	495.17	4.25
Carrot C-1	6.95	7.28	4.12	522.50	4.70
Carrot C-2	6.43	7.85	2.99	526.50	4.49
Carrot Desi Red	7.36	7.30	5.24	481.17	4.02
Carrot New Kuroda	7.78	8.70	3.55	478.50	4.04
HC-1	7.10	7.44	1.54	514.33	4.48
HC-2	7.75	8.63	2.45	535.50	4.15
Hisar Local-10	7.78	8.51	0.78	559.50	4.51
HC-118-2	7.26	7.26	3.57	465.16	2.97
HC-116	6.70	7.86	2.46	470.67	2.92
Jind Collection	6.38	8.01	2.20	507.00	4.18
HCY-235	7.13	8.06	3.62	525.17	4.19
HCY-183	7.50	8.85	0.96	494.67	3.76
HC-2B	7.30	7.97	1.14	508.33	4.29
HCB-22-1	6.38	6.69	2.93	471.83	4.21
HCP-227	7.76	8.14	2.82	474.00	4.15
HCP-118-1	6.65	7.75	1.96	583.66	4.38
Carrot NF-98	7.26	8.19	3.16	461.33	4.05
Nantes	7.26	10.10	4.03	467.83	4.57
Pusa Yamdagini	7.91	8.45	3.93	468.83	4.58
PC-31	7.83	8.18	4.95	553.33	4.51
PC-32	7.63	7.99	3.88	440.00	3.88
PC-33	7.63	7.88	3.61	529.33	4.53
PC-34	7.66	7.79	3.79	522.00	4.51
PC-35	7.70	7.93	5.01	516.33	4.37
GC-1	7.53	7.85	2.88	498.17	4.10
Selection-21	8.21	7.85	4.75	479.00	4.63
Pusa Kesar	7.43	8.67	3.52	470.83	4.91
CD (P=0.05)	0.54	0.52	0.83	28.41	0.32

Table 2. Range, mean, GCV, PCV, heritability in broad sense and genetic advance as percent of mean for different characters of carrot

Character	Range	Mean	GCV (%)	PCV (%)	Heritability	Genetic advance
TSS(%)	6.13-8.21	7.25	7.16	7.65	87.51	13.80
Dry matter(%)	6.60-10.11	7.94	7.70	7.85	96.20	15.55
Carotene content	0.78-6.10	2.95	50.14	50.20	99.77	103.18
Juice yield (ml)	440.00-559.45	497.94	5.39	5.71	89.11	10.47
Total sugars (%)	2.92-4.91	4.22	9.56	9.58	99.52	19.64

## Results and discussion

The extent of variability present in thirty eight genotypes of carrot was measured in terms of range, phenotypic coefficient of variation, genotypic coefficient of variation, heritability (broad sense) and genetic advance (Table 1 and 2). All the varieties differed significantly with respect to different characters studied. Wide range of variation was observed in all the characters. Total soluble solids varied from 6.13 (HC-195) to 8.21% (Selection-21), dry matter content from 6.69 (HCB-22-1) to 10.10% (Nantes), carotene content from 0.78 mg 100g<sup>-1</sup> (Hisar Local-10) to 6.10 mg 100g<sup>-1</sup> (Alipur Collection), juice yield from 440 ml kg<sup>-1</sup> (PC-32) to 559.5 ml kg<sup>-1</sup> (Hisar Local-10) and total sugars from 2.92% (HC-116) to 4.91% (Pusa Kesar). Bhatia *et al.* (2002) reported that HCY – 118 (8.87%) had highest T.S.S. followed by Hisar Gairic (8.77%) and HC- 199 (8.53%). Sambhi and Sukhija (1984) found that the percent dry matter was highest in Selection-233-10-75 B (9.70%) followed by Waryana Selection (8.90%). Kalloo *et al.* (1993) reported that the total carotenoid content on fresh weight basis was 9.62 mg/100g in Hisar Gairic compared with 4.70 mg/100g in Pusa Kesar. Kowalska *et al.* (2001) reported cultivar Nekharina as most suitable for processing for juice extraction. Bhatia *et al.* (2002), Saimbhi and Sukhija (1984), Kalloo *et al.* (1993) and Kowalska *et al.* (2001) also reported a wide range of variation for most of the characters studied in this crop. The GCV which gives a picture of extent of genetic variability in the population ranged from 5.39 (juice yield) to 50.14 % (carotene content). The GCV value was considerably high for carotene content. This character having higher range of variation and have a better scope of improvement through selection. A persual of data in Table 2 show that there was close relationship between PCV and GCV for all the characters which indicated less influence of environment for most of the characters.

Based on GCV alone, it is not possible to determine the amount of variation that is heritable. Heritable variation can be found with greater degree of accuracy when heritability is studied in conjugation with genetic advance. The heritability ranged from 87.51% (Total soluble solids) to 99.77% (carotene content). The genetic advance as per cent of mean from various characters revealed that carotene content (103.18) had high genetic advance. Though characters such as total sugar content, dry matter and juice yield had high heritability value, their GCV was comparatively less resulting in less genetic advance. Singh *et al.* (1987) observed that the expected genetic advance for T.S.S. (10.25%) was comparatively low in spite of their high heritability estimate (90.4%).

Burton (1952) suggested that GCV together with heritability estimate would give a better picture of genetic advance to be expected from selection. Swarup and Changale (1962) also pointed out that high heritability was not always accompanied by high genetic advance. Johnson *et al.* (1955) suggested that characters with high heritability coupled with high genetic advance would response to selection better than those with high heritability and low genetic advance.

Highly significant differences among the carrot genotypes were observed for all the characters under study. Wide variability exhibited in the carrot accessions indicated considerable scope for improvement through breeding and selection. GCV, PCV, heritability and genetic advance were high for carotene content

indicating ample scope of improvement through selection for this character.

## Acknowledgement

The authors are grateful to A.S. Tewatia, HAU Hisar, Director IIVR, Varanasi and the private seed companies for providing the seeds to carry out this work.

## References

- A.O.A.C., 1966. *Methods of vitamins assay*, Inter Science Publisher, New York, pp 97.
- Allard, R.W. 1960. *Principle of Plant Breeding*. John Willey and Sons Inc, New York, pp 85-95.
- Bhatia, M.K., K.S. Baswana, A.S. Tewatia and V.S. Panghal, 2002. Screening of carrot genotypes under high temperature conditions. *Haryana J. Hort. Sci.*, 31: 88-91.
- Burton, G.W. 1952. Quantitative inheritance of grasses. *Proc VIth Intl. Grassland Congress*, 1: 277-83.
- Burton, G.W. and E.M. Devane, 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.*, 45: 478-81.
- Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.*, 47: 314-18.
- Kaloo, G., A. Singh, D.S. Balyan, K.S. Baswana and P.S. Partap, 1993. 'Hisar Gairic' carrot bred for nutrition. *Indian Hort.*, 37: 21.
- Kowalska, M., E.J. Borowska and K. Majewska, 2001. Selected physical and chemical properties of carrot roots-industrial cultivars. *Inzynieria Rolnicza*, 5: 187-93.
- Swarup, V. and D.S. Changale, 1962. Studies on genetic variability in sorghum. I. Phenotypic variation and its heritability component in some important characters contributing towards yield. *Indian J. Genet.*, 22: 31-36.
- Saimbhi, M.S. and B.S. Sukhija, 1984. Evaluation of carrot varieties for processing. *J. Res. Punjab Agric. Univ.*, 21: 183-85.
- Singh, R., B.S. Sukhija and J. S. Hundal, 1987. Variability studies in carrot (*Daucus carota* L.). *Veg. Sci.*, 14: 33-36.