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RESEARCH ARTICLE

Genetic variability, heritability and genetic advance in varieties of carrot (*Daucus carota* L.)

■ **V.P. SANTHI, P.A. PRIYA, B. ANITA AND N. SELVARAJ**

SUMMARY

Investigations were carried out on yield and quality of sixteen varieties and six hybrids of carrot under two seasons in Nilgiri conditions during the year 2012-2013. The varieties were evaluated for *per se* performance, genotypic co-efficient of variances, heritability and genetic advance. Analysis of variance revealed the existence of significant differences among the varieties studied for all the characters. Based on the *per se* performance and variance, the variety Tokita Kuroda Improved was found to be the best with respect to growth, yield and quality attributes followed by Century Super Kuroda. In varieties high estimate of genotypic co-efficient of variation was observed for root splitting percentage, total chlorophyll, root carotene, leaf carotene and root forking percentage which indicates the potential possibility on improvement of these traits by restoring simple selection programme during *Kharif* and summer. The characters *viz.*, leaf carotene, root carotene, total chlorophyll, number of leaves and root weight exhibited higher values of heritability coupled with genetic advance as per cent of mean revealed that they may possibly controlled by additive genes. Hence, direct selection may be adopted to improve the characters under consideration during *Kharif* and summer, respectively.

Key Words : Genetic variability, Carrot varieties

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Carrot (*Daucus carota* L.) belongs to the family Apiaceae. It is a cool season crop and is grown all over the world in spring, summer and autumn in temperate countries and during winter in tropical and subtropical countries. It has got fleshy edible tap root which is botanically designated as conical root. Carrot has two groups: Asiatic and European (temperate) types. The world-wide consumption of carrot has increased over the years and it is now one of the most popular vegetable crops.

The Asiatic carrots are generally red coloured because of anthocyanin pigment. The European types are orange coloured because of carotene, a precursor of vitamin A. In India mostly Asiatic type is grown probably due to appealing red colour. Carrot increases the quantity of urine and helps in the elimination of uric acid. Chopra

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
V.P. SANTHI, Horticultural Research Station (T.N.A.U.), Udhagamandalam, NILGIRI (T.N.) INDIA
Email: santhihortvip@yahoo.co.uk

Address of the Co-authors:
P.A. PRIYA, B. ANITA AND N. SELVARAJ, Horticultural Research Station (T.N.A.U.), Udhagamandalam, NILGIRI (T.N.) INDIA

(1933) reported that carrot cures diseases of kidney and dropsy. Dietary supplementation of a combination of carrot and orange juice has been found to reduce the oxidation of low-density lipoprotein in habitual cigarette smokers. The consumption of vegetables per capita per day in India is 135g against the requirement of 285g per capita per day. It indicates the necessity to raise the production of vegetables which can be achieved by bringing more area under vegetable cultivation and increasing the productivity as well.

The Nilgiris district of Tamil Nadu is a unique one in that it is a hill district totally and 90 per cent of the area is covered by horticultural crops like plantation crops, vegetable crops, flower crops etc. Potato and carrot are two major vegetable crops occupying major area. Hence, developing high yielding varieties with resistance of physiological disorders are of great importance. Selection of desirable genotypes must be performed with reliable estimates. The genetic parameters like co-efficient of variation, heritability and genetic advance provide a clear insight into the extent of variability and relative measure of the efficiency of selection of genotype based on phenotype, in a highly variable population. Hence, the present study was carried out to find the genetic parameters for yield, quality and resistance to physiological disorders suitable for Nilgiri conditions and its certain important traits in carrot.

MATERIAL AND METHODS

The present study on evaluation of carrot (*Daucus carota* L) hybrids for high yield and quality suitable to the Nilgiri conditions was conducted one each at Nanjanad farm of Horticultural Research Station, Tamil Nadu Agricultural University, Udhagamandalam and other in a farmer's field at Muthorai Palada, Udhagamandalam during the year 2012-2013. The land was brought to a fine tilth by repeated ploughing and harrowing. The clods were broken and debris were removed. The soil was levelled and made into raised beds with a plot size of $2 \times 1m^2$ and the height of raised beds was 30 cm. The experimental field was divided into 48 plots. The experiment was laid out in a Randomized Blocks Design. A total number of sixteen varieties were replicated three times subjected for the study. The seeds were sown with spacing of 10×15 cm and at a depth of 1 cm and covered with thin layer of soil. Thinning was done after 45 days of sowing. Five plants were selected at random from each plot for recording observations on 60, 75, 90 days after sowing and at harvest. The phenotypic and genotypic variances were estimated according to Lush (1940). The range of heritability and genetic advance were categorized according to Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The genotypic co-efficient of variation, phenotypic co-efficient of variation, heritability, genetic advance as per cent mean in *Kharif*, summer and pooled mean data are presented in Table 1, 2, 3 and Fig.1, 2.

The highest genotypic co-efficient of variation was observed during *Kharif* for root splitting percentage (45.44), followed by total chlorophyll (42.38), root carotenoid (35.88), leaf carotenoid (25.54), root forking percentage (26.93). However, a low genotypic co-

Table 1 : Variability, heritability and genetic advance as per cent of mean parameters in carrot varieties for fourteen characters during *Kharif*

Characters	Genotypic co-efficient of variation (GCV %)	Phenotypic co-efficient of variation (PCV %)	Heritability (%)	Genetic advance as per cent of mean
Plant height (cm)	9.48	11.63	66.51	15.93
Number of leaves	6.83	19.13	12.77	5.03
Leaf width (cm)	9.54	16.53	33.31	11.34
Root length (cm)	3.70	5.94	38.91	4.76
Root weight (g)	11.50	11.95	92.65	22.81
Root diameter (cm)	3.87	12.43	9.72	2.48
Inner core diameter (cm)	7.19	8.47	72.00	12.57
Root to top ratio	9.51	14.68	41.95	12.69
Splitting %	45.44	79.34	32.8	53.61
Forking %	26.93	36.17	55.43	41.30
Total chlorophyll (mg/g)	42.38	42.74	98.34	86.59
Leaf carotenoid (mg/g)	25.54	25.55	99.91	52.60
Root carotenoid (mg/g)	35.88	35.90	99.91	73.89
Yield/ha (tonnes)	8.36	14.21	34.67	10.14

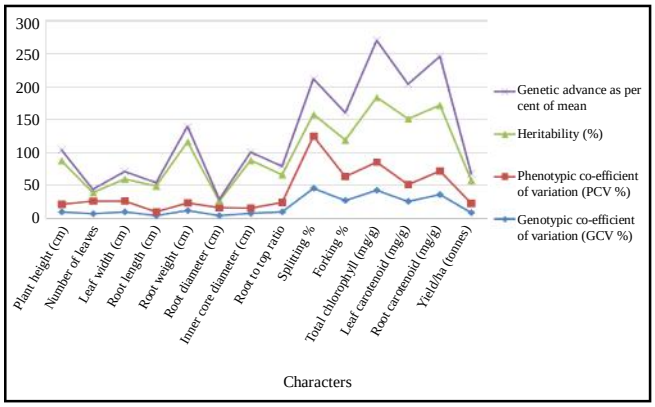

Fig. 1: Variability, heritability and genetic advance as per cent of mean parameters in carrot varieties for fourteen characters during *Kharif*

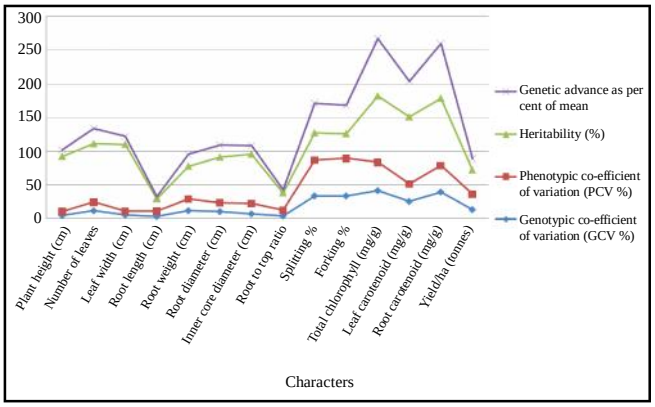

Fig. 2: Variability, heritability and genetic advance as per cent of mean parameters in carrot varieties for fourteen characters during summer

Table 2 : Variability, heritability and genetic advance as per cent of mean parameters in carrot varieties for fourteen characters during summer

Characters	Genotypic co-efficient of variation (GCV %)	Phenotypic co-efficient of variation (PCV %)	Heritability (%)	Genetic advance as per cent of mean
Plant height (cm)	4.91	5.42	82.03	9.16
Number of leaves	11.76	12.62	86.83	22.58
Leaf width (cm)	5.49	5.51	99.40	11.28
Root length (cm)	3.36	7.89	18.18	2.95
Root weight (g)	11.94	17.11	48.66	17.15
Root diameter (cm)	10.57	12.84	67.80	17.94
Inner core diameter (cm)	7.27	15.09	73.22	12.81
Root to top ratio	4.11	8.08	25.85	4.30
Splitting %	33.72	53.08	40.35	44.12
Forking %	33.68	55.69	36.58	41.96
Total chlorophyll (mg/g)	41.57	41.86	98.62	85.04
Leaf carotenoid (mg/g)	25.58	25.59	99.91	52.68
Root carotenoid (mg/g)	39.39	39.41	99.91	81.11
Yield/ha (tonnes)	13.52	22.54	35.97	16.70

Table 3: Pooled analysis of variability, heritability and genetic advance as per cent of mean parameters in carrot varieties for fourteen characters

Characters	Genotypic co-efficient of variation (GCV %)	Phenotypic co-efficient of variation (PCV %)	Heritability (%)	Genetic advance as per cent of mean
Plant height (cm)	6.35	7.45	72.60	11.15
Number of leaves	8.05	13.23	37.08	10.10
Leaf width (cm)	7.47	10.24	53.26	11.24
Root length (cm)	2.53	4.79	28.08	2.77
Root weight (g)	10.70	12.11	78.04	19.48
Root diameter (cm)	7.98	10.51	57.58	12.47
Inner core diameter (cm)	5.45	6.29	75.12	9.74
Root to top ratio	5.53	8.16	45.94	7.72
Splitting %	35.71	61.22	34.02	42.91
Forking %	24.32	34.12	50.81	35.71
Total chlorophyll (mg/g)	42.44	42.76	98.50	86.78
Leaf carotenoid (mg/g)	25.69	25.70	99.92	52.90
Root carotenoid (mg/g)	37.30	37.32	99.91	76.81
Yield/ha (tonnes)	11.54	15.64	54.49	17.55

efficient of variation was noticed for plant height (9.48), number of leaves (6.83), leaf width (9.54), root length (3.70), root diameter (3.87), inner core diameter (7.19), root to top ratio (9.51) and yield per hectare (8.36). In this study, high heritability values were leaf carotenoid (99.91), root carotenoid content (99.91), total chlorophyll (98.34), root weight (92.65), inner core diameter (72.00) and plant height (66.51). The lowest estimates of heritability were observed for number of leaves (12.77) and root diameter (9.72). The expected genetic advance expressed as percentage of mean was relatively high for the characters *viz.*, total chlorophyll (86.59), root carotenoid (73.89), root splitting percentage (53.61), leaf carotenoid (52.60), root forking percentage (41.30) and root weight (22.81).

In summer, highest genotypic co-efficient of variation was observed for total chlorophyll (41.57) followed by root carotenoid (39.39), root splitting percentage (33.72), root forking percentage (33.68) and leaf carotenoid (25.58). However, a low genotypic co-efficient of variation was noticed for the traits *viz.*, plant height (4.91), leaf width (5.49), root length (3.36), inner core diameter (7.27) and root to top ratio (4.11). In this study, high heritability values observed were root carotenoid (99.91), leaf carotenoid (99.91), leaf width (99.40), total chlorophyll (98.62), number of leaves (86.83), plant height (82.03), inner core diameter (73.22) and root diameter (67.80). The lowest estimates of heritability were observed for root length (18.18) and root to top ratio (25.85). The expected genetic advance expressed as percentage of mean was relatively high for the characters *viz.*, total chlorophyll (85.04), root carotenoid (81.11), leaf carotenoid (52.68), root splitting percentage (44.12), root forking percentage (41.96) and number of leaves (22.58). In pooled analysis, the highest genotypic co-efficient of variation was observed for total chlorophyll (42.44), root carotenoid (37.30), root splitting percentage (35.71), leaf carotenoid (25.69) and root forking percentage (24.32). However, a low genotypic co-efficient of variation was noticed for the traits *viz.*, plant height (6.35), number of leaves (8.05), leaf width (7.47), root length (2.53), root weight (10.70), root diameter (7.98), inner core diameter (5.45) and root to top ratio (5.53).

In this study, high heritability values were leaf carotenoid (99.92), root carotenoid (99.91), total chlorophyll (98.50), root weight (78.04), inner core diameter (75.12) and plant height (72.60). The lowest estimates of heritability were observed for root length (28.08).

The genetic advance expressed as percentage of mean was relatively high for the characters *viz.*, total chlorophyll (86.78), root carotenoid (76.81), leaf carotenoid (52.90), root splitting percentage (42.91) and root forking percentage (35.71).

The improvement in crop yield depends upon the magnitude of genetic variability available in breeding material and the extent to which the major yield component traits are heritable from generation to generation. The genetic variability can, thus, be a choice for selection of suitable parents, however, the quantitative characters are prone to environmental influence that necessitates the partitioning of overall variances as heritable and non-heritable components for efficient breeding programme (Hiremath and Rao, 1974). The present study reveals the extent of variability available in sixteen varieties collected from various sources and the scope of selection through heritability and genetic advance estimates and the results obtained are discussed here under. The analysis of variance revealed significant differences among the sixteen varieties for all the traits studied. The results supported the selection programme for high root yield.

Absolute variability in different characters cannot be considered as a critical factor for deciding as to which character is showing the highest degree of variability. The relative values of phenotypic and genotypic co-efficients of variation, therefore, give an idea about the magnitude of variability present in a population since the estimate of genotypic, heritability and expected genetic advance are useful for yield improvement and the above values were estimated to know the scope of improvement in the yield of carrot varieties. The measure of genotypic co-efficient of variation is necessary to understand the role of environmental influence on different traits. In the present investigation, the genotypes exhibited considerable amount of variability for all the fourteen traits studied.

Variability :

The highest genotypic co-efficient of variation was observed during *Kharif* for root splitting percentage followed by total chlorophyll, root carotenoid, leaf carotenoid and root forking percentage. In summer highest genotypic co-efficient of variation was observed for total chlorophyll followed by root carotenoid, root splitting percentage, root forking percentage and leaf carotenoid. This is in accordance with the findings of

Amin and Singla (2010). The phenotypic variance or phenotypic co-efficient of variation was slightly higher than genotypic variance or genotypic co-efficient of variation for all the characters indicating the presence of environmental influences to some extent in the expression of the characters. Similar results were also found by Tewatia and Dudi (1999) in carrot, Rabbani *et al.* (1998) in radish and Rahman *et al.* (2003) in tomato.

Low estimates of genotypic co-efficient of variation were observed for plant height, root length, inner core diameter, root diameter and root to top ratio in *Kharif* and plant height, root length, inner core diameter, root diameter and root to top ratio during summer. This experiment was in accordance with the results reported by Amin and Singla (2010) Jain *et al.* (2010) and Ullah *et al*. (2010).

Heritability and genetic advance :

Genotypic co-efficient of variation does not give an idea of total variation that is heritable. Further, it may not be feasible to determine the amount of heritable variation and the relative degree to which a character is transmitted from parent to offspring, by the estimate of heritability. Heritability estimate in broad sense alone, does not serve as the true indicator of genetic potentiality of the genotype since the scope is restricted by their interaction with environment. Hence, it is advisable to consider the predicted genetic advance as per cent of mean along with heritability estimate as a reliable tool in selection programme (Johnson *et al.,* 1955). Hence, both heritability and genetic advance as per cent of mean are determined to get a clear picture of the scope of improvement in various characters through selection.

In the present study, high heritability was observed for leaf carotene, root carotene content, root weight, inner core diameter, plant height, leaf width, total chlorophyll, number of leaves and root diameter. High heritability in broad sense indicated that large proportion of phenotypic variance was attributable to the genotypic variance and that these character differences among the genotypes were real and showed that the above mentioned traits with high heritability values were less influenced by the environment. The above findings are in close association with those of Brar and Sukhija (1981) and Tewatia and Dudi (1999) who reported high heritability for leaf length and root weight. High heritability for the characters controlled by polygenes might be useful to plant breeder for making effective selection. Genetic advance expressed as percentage of mean was relatively high for root carotene content. The results are in line with the findings of Amin and Singla (2010).

Low heritability was observed for root length and root to top ratio during both seasons and genetic advance expressed as percentage of mean was relatively low for the characters *viz.,* plant height, root length, root to top ratio and inner core diameter. The results are in line with the findings of Amin and Singla (2010) and Ullah *et al*. (2010), Yadav *et al*. (2009) for root length.

Since genetic co-efficient of variability, phenotypic co-efficient of variability and heritability estimates determine the component of heritable variation and genetic advance measures the extent of its suitability under selection, all these parameters should be considered simultaneously so as to bring effective improvement in yield and other characters.

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