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Studies on genetic variability and character association in temperate carrot

A.J. Gupta*, T.S. Verma, R. Bhat and S. Mufti****
Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT

One hundred genotypes including F_1 hybrids of temperate carrot were evaluated to investigate the genetic variability, correlation and path coefficient for eight characters. Analysis of variance showed highly significant differences for all the characters examined. High heritability in association with high genetic advance as percent of mean was observed for top length, gross weight/five plants and net root weight/five plants, indicating additive gene effects and emphasized the effectiveness of selection for these traits. The genetic correlations were higher than corresponding phenotypic ones for most characters implying inherent relationship among them. Net marketable root weight/plot expressed positive and significant genotypic association with top length (0.388), root girth (0.380), gross weight/five plants (0.516), net root weight/five plants (0.701) and gross weight/plot (0.873). Path analysis studies for net marketable root weight/plot revealed that gross weight/plot (0.721) is the most important yield contributing traits followed by net root weight/five plants (0.464) and number of marketable roots/plot (0.231). Hence, due emphasis should be given to these traits while selecting the genotypes for higher yield in carrot.

Key words: Genetic variance, heritability, correlation, selection parameters, European carrot.

INTRODUCTION

Carrot (*Daucus carota* L.) is an important root crop of the country. It is a rich source of pro-vitamin A and riboflavin. For the execution of breeding programme, the study of extent of variability is a pre-requisite. Similarly, the association and contribution of particular character for selection is studied by the path analysis. Carrot is an important vegetable, but very little information is available on its genetic potential for yield and yield contributing characters. Therefore, the present study was made to investigate the extent of genetic variability to know inter relationship of different characters and to understand the nature of direct and indirect effects of these characters on yield. The information on such aspects can be of great help in formulating appropriate breeding strategy for genetic enhancement of this crop.

MATERIALS AND METHODS

The experiment was carried out at Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi in the winter season for two years. One hundred European carrot genotypes were collected from different national and international sources. The experiment was laid out in a randomized block design with three replications. Each genotype was planted in a single row two metres long, spaced 45 cm apart with plant to plant spacing of 10 cm. The harvesting was done 97 days after sowing. All the recommended cultural practices were followed to maintain good growth of the crop. The observations were recorded from five randomly selected plants in each genotype per replication for top length (cm), root length (cm), root girth (cm), gross weight/five plants (g), net root weight/five plants (g), gross weight/plot (g), net marketable root weight/plot (g) and number of marketable roots/plot. Genotypic and phenotypic coefficients of variations were calculated according to the method suggested by Burton and DeVane (4). For the estimates of heritability and genetic advance (percent of mean), the methods of Hanson *et al.* (6), and Johnson *et al.* (8), respectively, were followed. Correlation coefficients of genotypic and phenotypic levels were calculated by Al-Jibouri *et al.* (1) and path coefficients (direct and indirect effects) by Dewey and Lu (5) methods.

RESULTS AND DISCUSSION

Significant differences among genotypes were observed for all the characters. The extent of variability was measured in terms of range, mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) along with the per cent of heritability (h^2), expected genetic advance and genetic gain are given in Table 1. A considerable amount of variation was observed for most of the characters. Net marketable root weight/plot and number of marketable roots/plot ranged from 855.0 to 2820.0 g

*Corresponding author's present address: Directorate of Onion and Garlic Research (ICAR), Rajgurunagar 410 505, Pune, Maharashtra; E-mail: guptaaj75@yahoo.co.in
** SKUAST-K, Shalimar, Jammu & Kashmir

Table 1. Estimates of variability for various traits in European carrot genotypes.

Character	Range	Grand mean ± SEm	Coefficient of variation		Heritability (h^2%)	Genetic advance (GA)	GA as percent of mean
			GCV	PCV			
Top length (cm)	17.9-64.4	30.32 ± 2.32	20.06	21.47	87.3	11.70	38.59
Root length (cm)	4.7-20.7	14.26 ± 1.31	14.32	17.03	70.7	3.54	24.82
Root girth (cm)	9.0-14.4	11.59 ± 0.77	8.73	10.99	63.1	1.66	14.32
Gross weight/five plants (g)	300.0-1800.0	663.30 ± 88.45	28.74	31.69	82.3	356.27	53.71
Net root weight/five plants (g)	250.0-900.0	498.85 ± 69.98	21.75	25.89	70.6	187.88	37.66
Gross weight/plot (g)	1170.0-4350.0	2463.39 ± 632.41	20.00	32.54	37.8	623.71	25.31
Net marketable root weight/plot (g)	855.0-2820.0	1824.55 ± 417.82	18.72	29.58	40.1	445.25	24.40
No. of marketable roots/plot	14.0-43.0	24.21 ± 6.47	18.48	32.52	32.3	5.24	21.64

and 14.0 to 43.0, respectively. Top length, root length, root girth, gross weight/five plants, net root weight/five plants and gross weight/plot varied from 17.9 to 64.4 cm, 4.7 to 20.70 cm, 9.0 to 14.4 cm, 300.0 to 1800.0 g, 250.0 to 900.0 g and 1170.0 to 4350.0 g, respectively. The variability was in agreement with those of Verma and Gupta (14). The PCV was higher than GCV for all the characters, indicating the role of environment in the expression of genotypes. The GCV estimates were maximum in gross weight/five plants (28.74) followed by net root weight/five plants (21.75), top length (20.06), gross weight/plot (20.00) and net marketable root weight/plot (18.72), which are important yield components. The results are in agreement with those of Hussain *et al.* (7), Kaur *et al.* (9), and Murlee *et al.* (10). Heritability estimates were high for top length (87.30%), gross weight/five plants (82.30%), root length (70.70%) and net root weight/five plants (70.60%); moderate and low for root girth (63.10%), net marketable root weight/plot (40.10%), gross weight/plot (37.80%) and number of marketable roots/plot (32.30%). In spite of high heritability values for most of the traits, estimates of expected genetic advance as percentage of mean ranged from 14.32 to 53.71.

High heritability values were associated with value of expected genetic advance as percent of mean for top length, gross weight/five plants and net root weight/five plants. High heritability accompanied by high genetic advance is more useful than heritability alone and considerable importance could be made in these characters by predicting the result and selecting the best individual (8). High heritability along with high genetic gain indicated in these characters was due to considerable additive gene effects (11). High expected genetic advance were recorded for gross weight/plot (623.71), net marketable root weight/plot (445.25) and gross weight/five plants (356.27).

In general, the genotypic correlation coefficients were higher in magnitude than the phenotypic ones, which revealed that the phenotypic expression of the correlation is reduced under the influence of environment, although there is a strong inherent association among various characters (Table 2). At genotypic level, net marketable root weight/plot found to be significantly and positively correlated with top length (0.388), root girth (0.380), net root weight/plant (0.701), gross weight/five plants (0.516) and gross weight/plot (0.873), which confirm well with the findings of Bhatia *et al.* (3), Singh *et al.* (12), Murlee *et al.* (10), and Tewatia *et al*. (13). Root length was significantly and positively correlated with top length (0.231). Root girth was significantly and positively correlated with top length (0.543), gross weight/five plants (0.662), net root weight/five plants (0.632), gross weight/plot (0.484) and net marketable root weight/plot (0.380). Net root weight/five plants was significantly positively correlated with top length (0.472), root girth (0.632), gross weight/five plants (0.825), gross weight/plot (0.689) and net marketable root weight/plot (0.701).

The path coefficient analysis was carried out by partitioning of phenotypic correlation coefficients into direct and indirect effects of various characters on net marketable root weight/plot (Table 3). Gross weight/plot (0.721) had highest direct effect on net marketable root weight/plot followed by net root weight/five plants (0.464) and number of marketable roots/plot (0.231). The direct selection for these characters would be beneficial for crop improvement since most of these characters also showed positive coefficient of correlation. Similar findings have been observed

Table 2. Estimates of genotypic (rg) and phenotypic (rp) correlation coefficients among various traits of carrot genotypes.

Character		Top length (cm)	Root length (cm)	Root girth (cm)	Gross weight/ five plants (g)	Net root weight/ five plants (g)	Gross weight/ plot (g)	Net marketable weight/plot (g)	No. of marketable roots/plot
Top length (cm)	rg	1.000	0.231*	0.543**	0.792**	0.472**	0.745**	0.388**	-0.292**
	rp	1.000	0.167	0.443**	0.738**	0.449**	0.496**	0.311**	-0.131
root length (cm)	rg		1.000	-0.206*	0.116	0.161	0.179	0.179	-0.026
	rp		1.000	-0.047	0.144	0.205*	0.172	0.187	0.023
Root girth (cm)	rg			1.000	0.662**	0.632**	0.484**	0.380**	-0.557**
	rp			1.000	0.596**	0.572**	0.407**	0.385**	-0.214*
Gross weight/five plants (g)	rg				1.000	0.825**	0.790**	0.516**	-0.534**
	rp				1.000	0.821**	0.546**	0.414**	-0.288**
Net root weight/five plants (g)	rg					1.000	0.689**	0.701**	-0.453**
	rp					1.000	0.481**	0.537**	-0.241*
Gross weight/plot (g)	rg						1.000	0.873**	0.016
	rp						1.000	0.885**	0.421**
Net marketable root weight/plot (g)	rg							1.000	0.170
	rp							1.000	0.495**
No. of marketable roots/ plot	rg								1.000
	rp								1.000

Table 3. Genotypic (G) and phenotypic (P) path coefficient effects of various characters of temperate carrot genotypes.

Character		Top length (cm)	Root length (cm)	Root girth (cm)	Gross weight/ five plants (g)	Net root weight/ five plants (g)	Gross weight/ plot (g)	No. of marketable roots/plot	Correlation with net marketable weight/plot
Top length (cm)	G	-0.149	-0.007	0.006	-1.035	0.313	1.143	0.072	0.388**
	P	**0.014**	0.002	0.034	-0.235	0.208	0.357	-0.030	0.311**
Root length (cm)	G	-0.034	-0.030	-0.002	-0.151	0.107	0.275	0.006	0.179
	P	0.002	**0.013**	-0.004	-0.046	0.095	0.124	0.005	0.187
Root girth (cm)	G	-0.081	0.006	0.011	-0.865	0.419	0.743	0.138	0.380**
	P	0.006	-0.001	**0.077**	-0.190	0.265	0.293	-0.049	0.385**
Gross weight/five plants (g)	G	-0.118	-0.003	0.007	-1.307	0.548	1.213	0.132	0.516**
	P	0.010	0.002	0.046	**-0.319**	0.381	0.393	-0.067	0.414**
Net root weight/five plants (g)	G	-0.070	-0.005	0.007	-1.078	0.664	1.057	0.112	0.701**
	P	0.006	0.003	0.044	-0.262	**0.464**	0.347	-0.056	0.537**
Gross weight/plot (g)	G	-0.111	-0.005	0.005	-1.033	0.457	1.535	-0.004	0.873**
	P	0.007	0.002	0.031	-0.174	0.223	**0.721**	0.096	0.885**
No. of marketable roots/ plot	G	0.044	0.001	-0.006	0.698	-0.301	0.025	-0.248	0.170
	P	-0.002	0.000	-0.017	0.092	-0.112	0.303	**0.231**	0.495**

Residual effect = 0.0979 (P), -0.0285 (G).

by Alves *et al.* (2), Bhatia *et al.* (3), Murlee *et al.* (10), and Tewatia *et al.* (13). Gross weight/five plants (0.393) had maximum positive indirect effect *via* gross weight/plot followed by net root weight/five plants (0.381) on net marketable weight/plot. Top length, root length, root girth, net root weight/five plants and gross weight/plot had positive indirect effects towards yield via net root weight/five plants and gross weight/plot. The characters which recorded direct positive effect on yield had indirect positive effect *via* each other. Therefore, they do not affect each other adversely and hence to select for improving the yield. Residual effect of the path analysis was very low (0.097) suggesting inclusion of maximum root yield influencing characters in analysis.

The path analysis revealed that gross weight/ plot, net root weight and number of marketable roots/ plot should be given more emphasis in the selection programme aimed at improving total root yield of carrot.

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