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Research Note

Variability, character association and path analysis for yield and yield attributes in carrot (*Daucus carota* L.)

P.A. Priya and V.P.Santhi*
Horticultural Research Station, Tamil Nadu Agricultural University, Ooty – 641 003
*Email: santhihortvip@yahoo.co.uk

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Abstract
The present investigation was undertaken during 2012 – 2013 with an objective to study the variability, heritability, character association and path analysis in sixteen genotypes of carrot. High estimate of genotypic coefficient of variation (GCV) was observed for root splitting percentage, total chlorophyll, root carotene, leaf carotene and root forking percentage. High heritability with high genetic advance as per cent of mean recorded for the characters *viz.*, leaf carotene, root carotene, total chlorophyll and root weight. Character association studies revealed the strong positive association of root yield with root carotene, root length, root weight, root diameter, inner core diameter, root forking percentage, root splitting percentage and leaf carotene. Path analysis indicated high positive direct effect of plant height, root length, root weight, root forking percentage, root splitting percentage and total chlorophyll on root yield.

Key words
Carrot, geneticvariability, heritability, genetic advance, correlation, path analysis

Carrot (*Daucus carota* L.) belongs to the family Apiaceae. It is a cool season crop and one of the most popular vegetable crop. Carrots are thought to originate from the Afghanistan region of Asia (Matskevitzh, 1929; Rubashevskaya, 1931). Carrot has two groups: Asiatic and European (temperate) types. The Asiatic carrots are generally red coloured because of anthocyanin pigment. The European types are orange coloured because of carotene. Carrots are the major single source of pro vitamin A, providing 14% to 17% of the total vitamin A consumption (Block, 1994; Heinonen, 1990). It is grown throughout the country and it contains 495 mg of β-carotene, vitamins, minerals and is a good source of calcium, potassium and magnesium. The major carrot growing states of India are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana. Schuphan and Weiller (1967) noticed antibacterial property in essential oil extracted from carrot roots. Carrot increases the quantity of urine and helps in the elimination of uric acid. Chopra *et al*., (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 present study was conducted to know variability, character association between yield and its components and direct and indirect effects on root yield in carrot and to evaluate the carrot varieties for high yield and quality suitable for Nilgiri conditions.

The experimental material consisted of sixteen varieties grown in randomized blocks design with three replications during *kharif*, 2012-2013 at Nanjanad farm of Horticultural Research Station, Tamil Nadu Agricultural University, Udhagamandalam. The seeds were sown with a spacing of 10 x 15 cm and at a depth of 1 cm. Observation were recorded on five randomly selected plants in each genotype for fourteen characters. For statistical analysis GENRES software was used. Heritability estimates as per Lush (1940), Genetic advance was computed as per Johnson *et al.* (1955), Correlation coefficients between yield and yield contributing characters were estimated as suggested by Burton (1952) and Path analysis was suggested by Dewey and Lu (1959).

The analysis of variance revealed significant differences among genotypes for all the characters indicating the presence of adequate variability among the genotypes. The estimates of mean, phenotypic and genotypic coefficients of variation (PCV and GCV), heritability in broad sense (h^2) and genetic advance presented in Table 1 revealed that PCV estimates of all characters were slightly more than that of GCV indicating the less influence of environment. High genotypic coefficient of variation for root splitting percentage, total chlorophyll, root carotene, leaf carotene and root forking percentage indicating that these traits can be effectively selected for improvement. The estimates of heritability were higher for leaf carotene, root carotene, root weight, inner core diameter, plant height and total chlorophyll. High heritability coupled with high genetic advance as per cent of mean (>20%) was observed with four yield components *viz.*, leaf carotene, root carotene, total chlorophyll and root weight. Similar results were reported by Brar and Sukhija (1981) and Tewatia and Dudi (1999), Amin and Singla (2010).

The genotypic correlation between different characters is given in Table 2.Genotypic correlation indicated that selection pressure for root carotene improves the root yield and showed significant positive association with yield. The root carotene, root length, root weight, root diameter, inner core diameter and leaf carotene showed positive association and also inter related among themselves indicating the possibility of selection of genotypes with higher in root carotene, root length, root weight, root diameter, inner core diameter and leaf carotene. These results are in accordance with the reports of Carlos *et al*. (2005) for root weight with root diameter. Hence, simultaneous selection based on these characters could be suggested for improvement in yield. On the other hand the characters *viz*., number of leaves, leaf width and root to top ratio recorded non significant and negative correlation associated with root yield. These results are in accordance with the reports of Hussain *et al*. (2008) and Ullah *et al*. (2010).

With a view to know the direct and indirect effects of these traits root yield correlations were further partitioned into direct and indirect effects through path coefficient analysis. The residual effect of 0.65 indicates that some more traits related to root yield need to be included (Table 3).

The results revealed that plant height, root length, root weight, root forking percentage, root splitting percentage and total chlorophyll exerted positive direct effect on root yield. Similar result was observed by Singh *et al.* (2002) for root length, Ullah *et al*. (2010) for plant height, Singh *et al*. (2005) for plant height, Shama *et al*. (2009) for root length.

Conclusion

Based on the foregoing discussion on character association and path analysis, it can be concluded that root length, root weight had strong positive correlation as well as high magnitude of positive direct effect on root yield. Hence it may be criteria in the selection of superior genotypes for root yield.

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Table 1. Variability and Genetic parameters for fourteen characters in carrot

Character	Mean	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability (%)	Genetic Advance as per cent of mean (%)
Plant height (cm)	48.20	9.48	11.63	66.51	15.93
Number of leaves	8.85	6.83	19.13	12.77	5.03
Leaf width (cm)	20.09	9.54	16.53	33.31	11.34
Root length (cm)	15.48	3.70	5.94	38.91	4.76
Root weight (g)	122.65	11.50	11.95	92.65	22.81
Root diameter (cm)	3.84	3.87	12.43	9.72	2.48
Inner core diameter (cm)	1.58	7.19	8.47	72.00	12.57
Root to top ratio	3.13	9.51	14.68	41.95	12.69
Splitting %	3.89	45.44	79.34	32.8	53.61
Forking %	4.35	26.93	36.17	55.43	41.30
Total chlorophyll (mg/g)	0.05	42.38	42.74	98.34	86.59
Leaf carotenoid (mg/g)	0.69	25.54	25.55	99.91	52.60
Root carotenoid (mg/g)	4.15	35.88	35.90	99.91	73.89
Yield/ha (tonnes)	28.52	8.36	14.21	34.67	10.14

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Table 2. Genotypic correlation coefficient among fourteen characters in carrot

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	1.0000													
X_2	0.0921	1.0000												
X_3	0.5149*	0.7540**	1.0000											
X_4	-0.0706	0.7354**	0.4304	1.0000										
X_5	-0.1994	0.5442*	0.3437	0.5639*	1.0000									
X_6	0.0108	0.8302**	0.7128**	0.7521**	0.5424*	1.0000								
X_7	-0.5820*	0.3067	-0.0924	0.2957	0.3174	0.1742	1.0000							
X_8	0.5056*	-0.6721**	-0.2625	-0.6672**	-0.4756	-0.5886*	-0.6238**	1.0000						
X_9	-0.3418	0.1262	-0.2466	0.2247	0.0699	0.1871	0.2374	-0.1799	1.0000					
X_1	-0.3046	0.2223	0.2061	0.0177	0.2402	0.1404	0.0319	-	0.1700	1.0000				
X_1	0.6663**	0.2692	0.3796	0.2967	-0.2452	0.1297	-0.3863	0.0323	-	-	1.0000			
X_1 2	-0.6266**	-0.3705	-0.4564	-0.4654	-0.3388	-0.3968	0.2989	0.0421	0.0779	0.2326	-0.6904**	1.0000		
X_1	-	0.0911	-0.1093	-0.0297	0.5709	0.1342	0.4562	-	0.1383	0.3722	-	0.5296	1.0000	
X_1	-0.5135*	-0.0133	-0.1518	0.0037	0.3517	0.0857	0.0705	-	0.3071	0.2844	-	0.3916	0.6763*	1.000

X_1 –Plant height (cm), X_2 – Number of leaves, X_3 – Leaf width (cm) , X_4 – Root length (cm), X_5 – Root weight (g),
X_6 –Root diameter (cm), X_7 – Inner core diameter (cm), X_8 – Root to top ratio , X_9 – Splitting % , X_{10} – Forking % ,
X_{11} –Total chlorophyll (mg/g) X_{12} – Leaf carotenoid, (mg/g), X_{13} – Root carotenoid (mg/g), X_{14} – Yield per hectare (tonnes)

*Significant at 5% level ** Significant at 1% level

Table 3. Genotypic path coefficient among root yield and its components in carrot

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	r_g with yield
X_1	1.189	-0.104	-0.397	0.001	0.136	-0.490	0.205	-0.959	0.327	0.293	0.032	0.067	-0.010	-0.513
X_2	0.225	-0.550	-0.176	0.002	1.157	-0.734	0.072	-0.079	0.080	0.236	0.038	0.063	-0.002	-0.013
X_3	1.002	-0.205	-0.472	0.001	0.211	-0.591	0.242	-0.845	0.214	0.519	0.034	0.058	-0.007	-0.151
X_4	0.143	-0.223	-0.082	0.005	0.809	-0.106	-0.228	0.468	-0.148	-0.206	0.004	-0.043	-0.036	0.003
X_5	0.137	-0.538	-0.084	0.004	1.183	-0.712	-0.071	0.200	0.048	0.273	0.020	0.097	-0.015	0.351
X_6	0.696	-0.482	-0.332	0.001	1.005	-0.838	0.066	-0.645	0.222	0.485	0.028	0.132	-0.006	0.085
X_7	-0.392	0.064	0.184	0.002	0.135	0.089	-0.621	0.375	-0.082	0.093	-0.015	-0.058	-0.015	0.070
X_8	1.102	-0.042	-0.385	-0.002	-0.229	-0.522	0.225	-1.035	0.368	0.463	0.037	0.087	0.005	-0.075
X_9	0.910	-0.103	-0.236	-0.002	0.134	-0.436	0.119	-0.892	0.427	0.630	-0.033	0.038	0.003	0.307
X_{10}	0.336	-0.125	-0.235	-0.001	0.311	-0.391	-0.056	-0.461	0.259	1.039	0.036	-0.085	-0.011	0.284
X_{11}	0.337	-0.186	-0.140	0.000	0.212	-0.209	0.080	-0.335	-0.123	0.331	0.114	0.062	0.008	-0.620
X_{12}	-0.254	0.110	0.087	0.001	-0.366	0.351	-0.115	0.287	-0.051	0.279	-0.023	-0.314	-0.028	0.391
X_{13}	0.203	-0.024	-0.061	0.003	0.327	-0.097	-0.165	0.101	-0.026	0.200	-0.016	0.161	-0.056	0.676

Residual effect = 0.6510 $r_{g\,=}$ Genotypic correlation coefficient

X_1 –Plant height (cm), X_2 – Number of leaves, X_3 – Leaf width (cm) , X_4 – Root length (cm), X_5 – Root weight (g),
X_6 –Root diameter (cm), X_7 – Inner core diameter (cm), X_8 – Root to top ratio , X_9 – Splitting % , X_{10} – Forking % ,
X_{11} –Total chlorophyll (mg/g) X_{12} – Leaf carotenoid, (mg/g), X_{13} – Root carotenoid (mg/g), X_{14} – Yield per hectare (tonnes)