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Assessment of genetic variability, character association, heritability and path analysis in European carrot (*Daucus carota* var. *sativa*)

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ABSTRACT

Studies of genetic variability and relationship among the 40 genotypes of European carrot (*Daucus carota* L. var *sativa*) for important horticultural traits revealed wide range of variability for the traits. Little or no differences between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for all traits confirmed low environmental influence. High PCV for root diameter, root weight, root yield and flesh thickness indicated additive gene action. High heritability with high to moderate genetic advance for flesh thickness, root length, root diameter suggested additive gene action and scope for improvement through selection. Higher genotypic correlation revealed inherent association among the traits. Strong character association of root weight, root length, and crown diameter with root yield suggested as selection criteria for higher yield. Adequate genetic variability within the germplasm indicated enormous scope for genetic improvement of yield and quality traits. Root weight had maximum direct effect on root yield (q/ha). It was concluded that selection based on root weight, root length, root diameter and crown diameter may improve yield.

Key words: Correlation, *Daucus carota*, Genetic advance, Heritability and Path analysis

Carrot (*Daucus carota* L.) 2n=2×=18 belongs to family Apiaceae and occupies a pride place in the market due to its delicious taste, flavour and nutritive values. It is an important root vegetables grown throughout India on an area of 88.00 thousand ha with 1446.00 thousand tonnes production and 164.30 q/ha productivity (NHB 2017). It has two groups: Asiatic and European (temperate) types. Asiatic carrots are red in colour due to anthocyanin pigment whereas European types are orange colour because of carotene (Priya and Santhi 2015). It is a major source of vitamin A and provides 14 to 17% of total vitamin A (Block 1914). The improvement in yield and quality normally achieved by selecting the genotypes with desirable characters combinations existing in nature or created by hybridization. However, yield is a complex character and its direct improvement is difficult. Thus present study was undertaken to investigate the extent of genetic variability to know their inter relationship of different characters and to understand the direct and indirect effect of these characters on yield.

MATERIALS AND METHODS

The present investigation was carried out at experimental farm of the ICAR, Srinagar for two consecutive years (2014 and 2015). The material consisted of 40 variable genotypes (SH-C-136, SH-C-7-5-1,SH-C-2007,SH-C-9005B,Yellow Root,SH-C-75,SH-C-33,SH-C-42,SH-C-12, SH-C-58,SH-C-39,SH-C-95,SH-C-11,SH-C-54,CITH-C-1,CITH-C-5,SH-C-141,SH-C-151,AMERICAN,SH-C-19,SH-C-25,KASHMIRY BLACK, PINK CARROT,SH-C-20,SH-C-121-1,SH-C-120,NANTES TYPE,SH-C-101,SH-C-51,SH-C-7-3-2,SH-C-27,SH-C-150,SH-C-52-05B,SH-C-124,SH-C-134,SH-C-152,SH-C-38,SH-C-59{LT},SH-C-22,SH-C-52-1) collected from different carrot growing hot spots in temperate regions of Kashmir valley and heterotic selection from carrot lines bred at CITH. Seeds were sown at 30 × 10 cm inter and intra row spacing in mid of August in plot size of 3×2 m in randomized block design with three replications. The experimental site lies between latitude of 34º05' N and longitude of 74º50'E and at an altitude of 1640 m amsl. The average maximum 19.63°C and minimum 6.52°C temperature, amount of rainfall 160.72 mm and relative humidity 58.35%, evaporation 2.45 and soil characteristics, viz. pH= 6.81, EC = 0.36 dS/m recorded during the cropping season i.e. August to November. Recommended agronomic and cultural practices were followed to obtain better phenotypic expression of the characters. Observations were recorded on top length, petiole length, number of leaves/plant, leaf weight/plant, root weight, leaf root ratio, root length, root diameter, core thickness, crown diameter, flesh thickness and root yield (q/ha). The pooled data over two years were analysed as per

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the method suggested by Gomez and Gomez (1958). The variance component and coefficient variation were worked out following Allard (1960).The heritability in broad sense and expected genetic advance were computed according to Johnson *et al.* (1955). Estimates of genotypic and phenotypic variance were obtained by using the Formulae given by Al-Jibouri *et al.* (1955). The correlation and path analysis was calculated as method suggested by Miller *et al.* (1958) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

Forty genotypes involved in the study varied significantly for all horticultural traits. The mean sum of square was highly significant for most of the traits indicating the presence of high variability in genotypes studied (Table 1). Maximum variability was observed for root yield (q/ha), core thickness (mm), leaf length and crown diameter. The results were in conformity of findings of Asima *et al.* 2013. The high variable traits may be used for selection programme of European carrots. The extent of variability was measured in terms of range, mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) along with heritability (h^2), expected genetic advance and genetic gain (Table 2). The mean leaf length ranged from 21.50 cm (Pink carrot) to 58.80 cm (SH-C-7-3-2). The range of variation for number leaves/plant was from 5.00 (SH-C-52-1) to 14.00 (SH-C-101), root weight from 45 g (SH-C-136) to 183 g (SH-C-12), root diameter from 18.38 mm (Nantes type) to 42.72 mm (CITH-C-5), root length from 119.00 mm (Nantes type) to 179.00 mm (CITH-C-5). The core

Table 1 Mean square of different traits in European Carrot genotypes

Source of variation	Degree of freedom	Leaf length (cm)	No. of leaves/ plant	Root weight (g)	Root diameter (mm)	Root length (mm)	Core thickness (mm)	Crown diameter (mm)	Flesh thickness (mm)	Yield (q/ha)
Replications	2	3.191**	0.308*	4.158**	0.069*	1.582**	13.308**	1.13**	0.410**	85.908**
Genotypes	39	191.938**	8.814*	2577.297**	33.210*	109.228**	444.545**	56.60**	19.710**	42203.688**
Error	78	0.652	.5668	1.149	0.107	0.495	1.137	0.312	0.123	33.951

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

Table 2 Range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advances (GA) in European carrot

Trait	Range		Genotype		Mean	Geno-typic variance (%)	Phenotypic variance (%)	Phenotypic coefficient variation (%)	Genotypic coefficient variation (%)	Heritability in broad sense (%)	Genetic advance (%)	Genetic gain means (%)
	Min	Max	Min	Max								
Leaf length (cm)	21.50	51.10	Pink carrot	SH-C-7-3-2	36.30	63.76	64.41	20.106	20.004	98.99	16.26	41.00
No. of leaves/ plant	5.00	14.00	SH-C-52-1	SH-C-101	9.50	2.75	3.32	20.365	18.543	98.49	7.39	34.78
Root weight (g)	45.00	183.00	SH-C-136	SH-C-12	114.00	858.72	859.87	29.637	29.617	82.90	5.40	60.99
Root diameter (mm)	18.38	42.72	Nantes type	CITH-C-5	30.55	11.03	11.14	51.248	51.000	99.87	19.02	104.52
Root length (mm)	119.00	179.00	Nantes type	SH-C-2	149.00	36.24	36.74	18.286	18.163	99.04	36.69	37.18
core thickness (mm)	6.34	16.93	SH-C-59(lt)	SH-C-27	11.64	147.80	148.94	8.079	8.048	98.65	1.07	16.51
Cown diameter (mm)	11.26	29.92	SH-C-59(lt)	CITH-C-5	20.59	18.76	19.07	18.663	18.510	99.24	12.47	37.83
Flesh thickness (mm)	0.56	17.15	SH-C-27	American	8.86	6.53	6.65	21.348	21.149	98.36	64.88	43.14
Yield q/ha	180.00	732.00	SH-C-136	SH-C-12	456.00	14056.58	14090.53	29.999	29.963	98.36	7.20	61.67

*Significant at 5% level, ** significant at 1% level thickness ranged from (6.54 mm (SH-C-59 (LT)) to 16.93 mm (SH-C-27), crown diameter from (11.26 mm (SH-C-59 (LT)) to 29.92 mm (CITH-C-1), and flesh thickness from 0.56 mm (SH-C-51) to17.15 mm (American). Root yield ranged from180 q/ha (SH-C-136) to 732 q/ha SH-C12). The range and mean differences of studied traits indicated the existence of genetic variability among genotypes for the majority of the characters, which reflected the presence of potential in the genotypes for improvement. Similar reports for variability in germplasm for various horticultural traits in carrot have been reported by Kumar *et al.* (2010), Gupta *et al.* (2012), Priya and Shanthi (2015). A close proximity in phenotypic and genotypic coefficient of variation was observed indicating a little influence of environment in the expression of various horticultural traits studied. This suggested that selection will be effective on the basis of genotype alone. Similar results have been reported by Singh *et al.* (2004) and Asima *et al.* (2013) in carrot.The estimate of heritability acts as a predictive instrument exercising the reliability of phenotypic value. Therefore, it helps a breeder to make a selection for particular character when heritability is high. Genetic advance is useful indicator of the progress that can be expected as a result of exercising the selection on pedigree. The heritability was very high for all the traits studied indicated less influence of environment on expression of these traits. Heritability coupled with genetic advance is more useful than heritability alone in predicting the result of selecting the best individual genotype as it suggests the presence of additive gene effects. High estimates of heritability along with higher genetic advance for root length, root diameter, flesh thickness, crown diameter root yield (q/ha) and high heritability with moderate genetic advance in root weight, root diameter, crown diameter and root yield (q/ha) indicated that heritability of these traits is mainly owing addictive effects and consequently genetic gain is expected under such situation. Similar result has been reported by Gupta *et al.* (2012) and Asima *et al.* 2013.

Genotypic and phenotypic correlation for root yield and yield components in carrot are presented in Table 3. The genotypic correlations were higher than their corresponding phenotypic correlation coefficient for all traits studied indicated strong inherent association between these traits which were in agreement with the findings of Singh *et al.* 2002, Bhatia *et al.* 2003 and Murlee *et al.* 2009. Results indicated that root yield exhibited highly significant positive genotypic and phenotypic correlations with root weight (0.999 and 0.997) and root length (0.802 and 0.796) crown diameter (406 and 400) respectively. A significant positive correlation with root length (814 and 806), crown diameter (0.778 and 0.770) flesh thickness (0.417 and 0.412) was observed with root weight and these characters may be considered a major root yield contributing traits in carrot. Hence, for effective crop yield selection should be oriented towards the higher value for these component characters like, root weight, root length, core diameter and flesh thickness. Significant and positive correlation in root weight, root length, core diameter and flesh thickness with root yield was also reported by Carlos *et al.* (2005) and Priya and

Table 3 Genotypic (G) and phenotypic (P) Coefficient correlation estimation among the traits of European carrot genotypes

Trait		Leaf length (cm)	No. of leaves/ plant	Root weight (g)	Root diameter (mm)	Root length (mm)	Core thickness (mm)	Crown diameter (mm)	Flesh thickness (mm)	Yield (q/ha)
Leaf length (cm)	G	1.000	0.316	0.084	0.271	0.067	0.141	0.000	0.318	-0.103
	P	1.000	0.314	0.081	0.2665	0.066	0.137	0.003	0.315	-0.097
No. of leaves/plant	G		1.000	0.204	-0.462**	0.218	0.295	0.339*	0.239	0.203
	P		1.000	0.183	-0.419**	0.207	0.269	0.312	0.217	0.187
Root weight(g)	G			1.000	0.113	0.814**	0.237	0.778**	0.417**	0.999**
	P			1.000	0.1132	0.806**	0.235	0.770**	0.412**	0.997**
Root diameter(mm)	G				1.000	0.207	-0.295	0.092	-0.051**	0.110
	P				1.000	0.202	-0.292	0.089	-0.051	0.109
Root length (mm)	G					1.000	0.039	0.706**	0.356	0.802**
	P					1.000	0.0401	0.690**	0.346*	0.796**
Core thickness (mm)	G						1.000	0.132	-0.069	0.246
	P						1.000	0.132	-0.065	0.245
Crown diameter(mm)	G							1.000	0.683**	0.768**
	P							1.000	0.670**	0.760**
Flesh thickness(mm)	G								1.000	0.406*
	P								1.000	0.400*
Yield (q/ha)	G									1.000
	P									1.000

*Significant at 5% level, ** significant at 1% level

Table 4 Estimates of direct and indirect effect of significant traits on yield of European carrot

Character	Leaf length (cm)	No. of leaves/ plant	Root weight (g)	Root diameter (mm)	Root length (mm)	Core thickness (mm)	Crown diameter (mm)	Flesh thickness (mm)	Yield (q/ha)
Leaf length (cm)	0.0012	0.0005	0.3269	0.0002	0.0082	0.0002	0.0021	0.0000	0.3179
No. of leaves/plant	0.0001	0.0046	0.2115	-0.0013	0.0066	0.0010	0.0049	-0.0014	0.2027
Root weight (g)	0.0004	0.0009	0.0358	0.0003	-0.0244	0.0008	-0.0113	-0.0025	1.0000
Root diameter (mm)	0.0001	-0.0021	0.1176	0.0028	0.0062	-0.0010	-0.0013	0.0003	0.1101
Root length (mm)	0.0003	0.0010	0.8428	0.0006	-0.0300	0.0001	-0.0103	-0.0021	0.8024
Core thickness (mm)	0.0001	0.0014	0.2450	-0.0008	-0.0012	0.0033	-0.0019	0.0004	0.2462
Crown diameter (mm)	0.0002	0.0016	0.8055	0.0003	-0.0212	0.0004	-0.0146	-0.0041	0.7681
Flesh thickness (mm)	-0.0000	0.0011	0.4317	-0.0001	-0.010	-0.0002	-0.0099	-0.0060	0.4057

Residual effect -0.0215

Santhi 2015.Root length was significantly and positively correlated with crown diameter (0.706). Crown diameter was significantly correlated with flesh thickness (0.683).

Path coefficient analysis splits the total correlation and coefficient of different characters in direct and indirect effect on root yield in such a manner that the sum of direct and indirect effect is equal to genotypic correlation (Table 4). The data indicated that root weight showed the highest positive direct effect (0.0358) on yield (q/ha) followed by core thickness (r=0.0033), root diameter (r=0.0046), leaf length (r=0.0012), whereas root length (r =-0.030), crown diameter (r= -0.0146) and flesh thickness (r=-0.0146) showed negative direct effect on yield (q/ha). The positive indirect effect of leaf length was found on yield (q/ha) via number of leaves/plant (r=0.0005), root weight (r=0.3259), root diameter (r=0.0002), core thickness (r=0.0002) and crown diameter (r=0.0021) whereas, number of leaves per plant showed positive indirect effect via leaf length (r=0.0001), root weight (r =0.2115), root length (r=0.0066), core thickness (r=0.0001) and crown diameter (r=0.0049). Root weight reflected indirect positive effects on root yield via leaf length, number of leaves/plant, root diameter and core thickness. Root diameter contributed positively to yield indirectly via leaf length (r=0.0001), root weight (r=0.1176) root length (r=0.0062) and flesh thickness (0.0003). Root length showed positive indirect effects on root yield (q/ha) via leaf length, number of leaves per plant, root weight, root diameter and core thickness whereas core thickness indirectly affected the root yield via leaf length (r=0.0001), number of leaves per plant (r=0.0014), root weight (0.2450) and flesh thickness (r=0.0004). Crown diameter also contributed positively to the root yield (q/ha) indirectly via leaf length (r =0.0002), number of leaves plant (r =0.0016), root weight (r=0.8055), root diameter (r =0.0003) and core thickness (r=0.0004), whereas flesh thickness contributed to yield (q/ha) indirectly via, number of leaves per plant, root weight. Due to high positive direct effects of root weight, number of leaves per plant, root diameter, core thickness and their significant and positive corelation with root yield as well as high heritability with genetic advance showed the importance of these traits in carrot improvement similar observations have been made by Alves *et al.* (2006) and Gupta *et al.* (2012) . The unexplained variation in genotypic path coefficient was 0.0215. It indicated that most of the traits involved in expression of variability have been taken into consideration in this study.

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