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G x E interaction and stability analysis in carrot (*Daucus carota* L.)

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ABSTRACT

G X E interaction and stability analysis was carriedout in four environments comprised of two different dates of sowing with two different locations for 24 diverse lines of carrot obtained from different sources. The analysis of variance for stability analysis revealed that variance for genotype x environment interactions was significant for weight of root per plant, length of root, plant top height, root laterals and total soluble sugar. The genotypes JDNCT-8, JDNCT-18, JDNCT-36, JDNCT-39, JDNCT-40 and Mehsana local-3 were identified as stable for weight of root per plant. The genotypes JDNCT-24, JDNCT-34 and JDNCT-35 were found better for favorable environments, among these three genotypes JDNCT-34 have the highest average weight of root.

Key words : Carrot, G x E interaction and stability.

Carrot (*Daucus carota* L.), is an important root vegetable root crop worldwide, both economically and as a source of provitamine 'A' carotenes. Carrot is cultivated in India, China, Malaysia, Indonesia, Philippines, European countries, West Africa and north-south America. In India the major carrot growing states are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana. This plant species originated in Afghanistan (Matskevitzh, 1929) and spread to the Mediterranean region by the tenth to twelfth century and to Europe and China in the fourteenth century. Orange carrots were first known in the seventeenth century in northern Europe. Before that only yellow and purple root carrot types were cultivated. The cultivated types of this species can be readily crossed with wild *Daucus carota* L., which is distributed worldwide. Approximately 80 *Daucus* species have been identified. Almost all species, including carrot, are diploid, where n = 7 to 11. The only reported interspecific cross with carrot is with *Daucus capillifolius*, where n = 9 for both species (Simon, 1993).

As environment is not static, each organism attempts to cope-up with environmental fluctuations through individual and population buffering (Cook and Johnson, 1968). The stability in productivity of a root crop like carrot over the years and locations is necessary as it is highly sensitive to adaphic factors and environmental fluctuations. Therefore, it is important to isolate genotypes manifesting low genotype x environment interaction in respect to carrot root yield and other important characters.

MATERIALS AND METHODS

The present research was conducted in four environments comprised two different dates of sowing with two different locations *viz.*, at Botanical Garden, Department of Genetics and Plant Breeding, C.P.College of Agriculture, S.D.Agricultural University, Sardarkrushinagar and Main Potato Research Station, S.D.Agricultural University, Sardarkrushinagar Deesa,. during *rabi*.2011-2012. Diverse 24 genotypes were selected from different sources for exprementation. Each genotype was planted with a spacing of 30 cm between rows and

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10 cm within row. The experiment was laid out in a Randomized Block Design with three replications. Observations were recorded for the traits *viz.*, number of leaves per plant, petiole length (cm), length of root (cm), root diameter (cm), weight of root (g/ plant), plant top height (cm), root laterals, core size (mm), harvest index (%), root index, total biomass, â-carotene contents (µg/g) and total soluble sugar. Analysis of variance was performed as per method suggested by Snedecor and Cocharan (1937) and review by Panse and Sukhatme, (1978). The statistical analysis for G x E interaction and stability parameters were carried out according to the Eberhart and Russell (1966).

RESULTS AND DISCUSSION:

The pooled analysis over environments revealed the variance due to was significant for nine characters out of 13 studied., which include number of leaves per plant, petiole length, length of root, weight of root, plant top height, core size, harvest index, β-carotene and total soluble sugar (Table 1.) The value of environmental variance were significant for 11 characters. The value of variance due to G x E interaction was also significant for seven characters (Table 2). These indicated that studied genotypes responded differently to array of environments and environments also showed variation. The mean squares due to G x E interactions were significant for length of root, weight of root, plant top height, root laterals and total soluble sugar while the interactions were non-significant for rest of the traits *viz.*, number of leaves per plant, petiole length, root diameter, core size, harvest index, root index, total biomass and β-carotene. Therefore, stability parameters were estimated for the characters which had significant estimates of G x E interaction.

On the basis of which stability parameters estimates those two genotypes *viz.*, JDNCT-8 and JDNCT-35 registered higher mean length of root, non-significant value of S^2d_i and value of regression coefficient was less than one, there by both were found better for poor environment. One genotype (Pusa Ashita) registered higher length of root, non significant deviation from regression and $b_i>1$. Thus it could be the most adapted for favorable environments only.

The perusal of stability parameters for weight of root per plant revealed that six genotypes

Table 1 Pooled analysis of variance (mean square) over environment for different characters in carrot

Sources of variation	d.f	Number of leaves per plant	Petiole length (cm)	Length of root (cm)	Root diameter (cm)	Weight of root (g/plant)	Plant top height (cm)	Root laterals	Core size (mm)	Harvest index (%)	Root index	Total Biomass	β-Carotene contents (µg/g)	Total Soluble sugar
Genotype	23	2.92*	52.69**	7.41*	0.23*	912.51**	141.96**	0.63**	18.97**	186.48**	0.64**	2841.33**	160.0**	7.64**
Environment	3	6.39*	200.84**	67.22*	49.66*	140744.25**	10998.4**	14.65**	651.75**	1225.17**	37.69**	520982.3**	2.59**	2.72**
G x E	69	1.87*	13.00**	5.50*	0.28*	866.50**	60.78**	0.75**	22.21**	143.44**	0.49**	2424.35**	3.27**	0.84**
Pooled error	184	1.63*	10.93**	3.85*	0.24*	162.05**	30.09**	6.64**	2.34**	*80.56***	*0.53***	*644.11***	*0.16***	*0.02***

*, ** Significant at 5 and 1 per cent levels, respectively.

were stable over range of environments. These genotypes registered higher mean weight of root, regression coefficient approaching unity and non-significant deviation from regression (Table 3) and the genotypes were JDNCT-8, JDNCT-18, JDNCT-36, JDNCT-39, JDNCT-40 and Mehsana local-3. Based on unit regression coefficient and least deviation from regression, twelve genotypes *viz.*, JDNCT-11, JDNCT-13, JDNCT-18, JDNCT-27, JDNCT-34, JDNCT-38, JDNCT-39, JDNCT-41, JDNCT-42, Mehsana local-1, Mehsana local-2 and Mehsana local-3 were found stable over wide range of environments for plant top height (Table 3) and also registered higher mean, regression coefficient close to unity and non- significant deviation from regression. The stability parameters showed be marked out for the characters, which had significant value of only G x E (L), otherwise, when both G x E (L) and G X E (NL) are significant. These magnitude should be considered GxE (L) > G x E (NL). In this regards stability parameters should be estimated for the characters length for roots, weight of root, plant top height and total soluble sugars.There is no stand for linear and non linear components of G x E interaction.

For total soluble sugar based on unit regression and least deviation from regression coefficient, three genotypes JDNCT-22, JDNCT-32 and JDNCT-34 were found to be ideally stable over large spectrum of environment for total soluble sugar. Genotypes *viz.*, JDNCT-11, JDNCT-13, JDNCT-14 and JDNCT-18 registered higher mean of total soluble sugar, non-significant S^2d_i and b_i > 1 (Table 3), Therefore, these genotypes could be considered as well adopted to favorable environments. The genotype Mehsana local-1 had higher mean, non-significant S^2d_i and regression coefficient less than one, which revealed that the said genotype would be well adapted to poor environments.

An overall basis of stability parameters (Table 4) revealed that none of the genotypes was stable for all the characters. For weight of root and other component characters, the genotypes JDNCT-8, JDNCT-18, JDNCT-36, JDNCT-39, JDNCT-40 and Mehsana local-3 were stable across environments. The genotypes JDNCT-24, JDNCT-34 and JDNCT-35 were found better for favorable environments.

Table 2 Analysis of Variance (mean squares) for stability for various traits in carrot

Sources of variation	d.f	Number of leaves per plant	Petiole length (cm)	Length of root (cm)	Root diameter (cm)	Weight of root (g/plant)	Plant top height (cm)	Root laterals	Core size (mm)	Harvest index (%)	Root index	Total Biomass	β-Carotene contents (µg/g)	Total Soluble sugar
Genotype	23	0.97	17.56**	2.6*	0.079	304.158**	499.17*	1.71	6.32	62.16	0.21	947.12	938818.87**	2.56**
Environment	3	2.13	669.47**	25.17*	16.56**	46914.67**	5900.79*	6.66	217.25**	408.34	12.56**	173660.80**	907562.85**	0.91
G x E	69	0.62	4.34	1.74*	0.92	288.84**	498.73**	2.35**	7.402	47.82	0.16	808.13	10597.57	0.28**
E + (G x E)	72	0.69	32.05**	2.71**	0.78**	2231.58**	723.82**	2.53	16.15**	62.84	0.68**	8010.32**	10534.15	0.31**
Environment (Linear)	1	6.40	2008.47*	75.52	49.67**	140744.37*	17702.95**	19.97	651.75	1225.18	37.69*	520982.53*	27226.942	2.72
Genotype x Environment (Linear)	23	0.72	2.54	2.67*	0.07	418.85*	948.94**	1.84	5.42	39.39	0.20	563.12	31325.927	0.56**
Pooled deviation	48	0.55	5.02	1.22	0.09	114.50	262.22**	2.49	8.04**	49.86	0.14	891.85	22366.11	0.13
Pooled error	184	1.63	10.9	3.85	0.24	162.05	34.95	6.64	2.34	80.56	0.53	2006.13	31252.774	0.02

*, ** Significant against pooled deviation mean square at 5 and 1 per cent level of significance, respectively.

Table 3 Stability parameters of different genotypes for length of root (cm), weight of root (g/plant), plant top height (cm), root laterals and total soluble sugar in carrot

Sr. No.	Genotypes	Length of root (cm)			Weight of root (g/plant)			Plant top height (cm)			Root laterals			Total soluble sugar		
		Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$
1.	JDNCT-8	16.88	0.04*	-0.38	94.35	0.80	-310.58	57.47	0.85	-428.71	1.74	4.65**	-1.21	4.09	-0.53*	-0.01
2.	JDNCT-11	15.95	1.12	1.03	87.15	0.88	58.55	66.95	0.70	-505.92	2.44	0.49	-1.68	6.55	2.77*	0.05
3.	JDNCT-13	16.12	0.55	-1.07	89.38	0.74	115.32	65.01	0.76	-501.13	2.52	1.03	-1.81	6.58	2.52*	0.09
4.	JDNCT-14	16.74	1.01	5.93	84.71	0.85	-33.24	58.47	0.77	-518.02	2.38	0.90	-1.34	7.15	4.44*	0.12
5.	JDNCT-18	15.49	2.63**	-0.52	99.55	1.14	53.05	62.43	0.69	-419.59	2.07	0.60	-1.73	6.89	3.11*	0.34
6.	JDNCT-21	14.43	1.53*	-1.07	85.12	1.10	51.26	60.14	3.28**	-501.63	2.87	1.36	-1.58	6.63	0.41*	-0.01
7.	JDNCT-22	15.98	2.20*	-0.47	92.97	1.25	27.20	56.74	0.80	-476.88	1.97	0.29*	-2.05	7.11	1.81	0.08
8.	JDNCT-24	15.18	1.30	-1.21	99.25	1.44*	-262.58	59.28	0.72	-482.46	2.03	0.84	-2.03	5.78	4.29**	0.01
9.	JDNCT-27	16.31	0.87	-1.23	90.70	0.76	-24.21	66.28	0.81	-505.62	2.18	0.13*	-1.80	5.40	0.18*	0.05
10.	JDNCT-32	15.65	0.65	-1.20	84.85	0.91	130.86	61.32	0.67	-508.69	2.58	0.21*	-1.01	7.07	1.02	0.40
11.	JDNCT-34	17.27	0.51	-2.28	125.92	1.59**	-1476.92	64.43	0.63	-525.12	2.06	0.46*	-1.47	6.36	0.87	0.04
12.	JDNCT-35	16.11	0.06*	1.60	98.03	1.46**	-187.51	62.28	0.90	-499.05	2.12	1.13	-1.76	5.67	-0.06*	0.07
13.	JDNCT-36	15.36	2.62**	0.35	94.50	1.00	-28.01	61.30	0.87	-524.40	2.37	0.98	-2.13	5.03	-1.29*	0.01
14.	JDNCT-37	14.57	0.14*	-0.42	83.94	0.50	226.58	59.28	0.45	-436.80	2.28	0.97	-2.11	5.81	-1.62**	0.01
15.	JDNCT-38	15.58	2.21*	-0.76	91.10	1.13	153.26	63.74	0.91	-496.47	2.27	0.82	-1.86	4.77	0.44*	0.02
16.	JDNCT-39	16.45	0.51	-1.15	101.83	0.87	140.81	64.68	0.50	-522.13	2.36	0.05*	-1.44	5.39	0.48*	0.01
17.	JDNCT-40	17.07	0.81	-0.99	99.77	1.24	274.21	61.87	0.78	-519.36	2.20	0.10*	-1.93	5.32	-1.94**	0.22
18.	JDNCT-41	17.76	0.69	-0.63	91.21	0.82	-45.38	68.23	0.61	-519.79	2.10	0.91	-1.42	5.60	7.50**	0.18
19.	JDNCT-42	16.82	0.82	0.19	92.43	0.61	424.92	64.57	0.91	-514.31	2.37	0.97	-2.12	5.00	-0.08*	0.03
20.	Pusa Rudhira	16.20	1.18	0.06	88.53	1.02	124.16	60.90	1.02	-506.81	2.35	0.83	-2.05	5.27	-1.38**	0.02
21.	Pusa Ashita	16.87	2.38*	-0.05	92.81	0.94	-29.22	55.25	0.75	-495.52	2.31	-0.32	-1.91	5.70	0.79	0.61
22.	Mehsana local-1	16.17	0.43	-0.93	87.72	1.10	-30.62	65.71	0.74	-498.91	2.29	1.30	-1.57	5.86	-1.33*	0.13
23.	Mehsana local-2	15.57	1.37	-0.91	88.78	0.79	-48.03	65.07	0.84	-486.52	2.75	0.98	-1.90	5.72	0.67	0.61
24.	Mehsana local-3	15.93	0.87	0.58	98.52	1.05	72.60	64.73	1.03	-486.78	2.45	1.32	-1.71	5.57	0.94	0.02
Mean		16.10			93.46			62.34			2.29			5.84		
S.Em. ±		0.64			8.45			9.34			0.91			0.21		

Table 4 Stable genotypes identified on the basis of high mean for weight of root per plant and stability parameters

Genotypes	Weight of root per plant	Stable for other traits
JDNCT-8	94.35	-
JDNCT-18	99.55	3, 4+
JDNCT-24+	99.25	-
JDNCT-34+	125.92	3+
JDNCT-35+	98.03	-
JDNCT-36	94.50	3
JDNCt-39	101.83	1, 2, 3+
JDNCT-40	99.77	1, 3+
Mehsana local-3	98.52	3

Where,
+ = Better for favorable environments
1 = Length of root
2 = Plant top height
3 = Root laterals
4 = Total soluble sugar

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