The Pharma Innovation Journal 2023; 12(6): 4209-4213

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 4209-4213

www.thepharmajournal.com
Received: 09-03-2023
Accepted: 11-04-2023

JS Dapke
Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

PB Vanave
Assistant Professor, Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

GB Vaidya
Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

V Bariskar
Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

MR Naik
Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

Corresponding Author:
PB Vanave
Assistant Professor, Department of Agriculture Botany, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Maharashtra India

Genotype x environment interactions and stability analysis for seed yield and yield attributing characters in castor (*Ricinus communis* L.)

JS Dapke, PB Vanave, GB Vaidya, V Bariskar and MR Naik

Abstract
The sixty one genotypes including 42 hybrids, 17 parents along with GCH 5 and GCH-7 as commercial checks were evaluated for stability in three environments. Three female lines *viz*; VP-1, SKP-84, JP-65 and fourteen male parents *viz*; JC-10, RG 1414, DCS 105, SKI 270, 48-1, RG-2275, MCI 8, VI 9, DCS 78, ANDC 8, DCS 107, JC-12, TMV-6, DCS-84 were crossed in Line x Tester design and evaluated along with two hybrid checks. The stability analysis indicated the presence of significant Genotype by Environment interaction for all the characters under study except oil content. Both linear and non-linear components of G x E interaction were significant for number of capsules on primary spike, seed yield per plant and 100-seed weight. Higher magnitude of mean squares due to environment (linear) indicated that differences between environments were considerable for all the characters and revealed that these characters were influenced by environments considerably. Among all the parents, 9 parents showed a high mean when compared with the experimental mean while top five parents *viz.*, SKP-84 ($\bar{X}$ = 173.66), SKI-270 ($\bar{x}$ = 168.52), DCS-84 ($\bar{X}$ = 167.11), 48-1 ($\bar{x}$ = 166.62) and TMV-6 ($\bar{X}$ = 163.19) were average responsive (bi ≈ 1) to all the environmental conditions with higher seed yield per plant. Forteen hybrids and check revealed average stable response. Among them top hybrids were SKP-84 x 270 ($\bar{X}$ =266.87), SKP-84 x TMV-6 ($\bar{X}$ =256.87), VP-1 x SKI-270 ($\bar{X}$ =255.44), SKP-84 x 48-1($\bar{X}$ =251.24), and SKP-84 x DCS 84 ($\bar{X}$ =248.01). None of the parents or hybrids was found consistently stable for all the characters in any environment.

Keywords: Castor, genotype x environment interaction, stability

Introduction
Castor is one of the most important non edible oilseed. In India, it is grown in an area of 8.24 lakh ha. with the production and productivity of 15.68 lakh tonnes and 1902 kg ha^{-1}, respectively (Anon, 2020) [3]. Stability parameters provide information about adaptability of genotypes and their stability over a wide range of agro-climatic conditions. According to Allard and Bradshaw (1964) [2], a genotype which can adjust its genotypic or phenotypic state in response to transient fluctuations in environments, in such a way that it gives high and stable economic returns over the time and space, can be termed as "well-buffered' or "highly buffered" genotype. Phenotype is defined as a linear function of Genotype (G), Environment (E) and G x E interaction effects. Relative importance of main and interaction effects may vary from genotype to genotype (Eberhart and Russell, 1966; Finley and Wilkinson, 1963; Perkins and Jinks, 1968) [4, 5, 13]. The study of G x E interaction serves as a guide for various environmental niches. It is possible to identify genotypes with stability for high yield, through the stability of yield and yield component characters. The present study was undertaken to identify stable hybrids and their parents for seed yield and component characters.

Materials and Methods
The experimental material was developed at the College Farm, Navsari Agricultural University, Navsari by crossing three females [pistillate lines] with fourteen males (Testers) in a line x tester mating system. Three female lines *viz*; VP-1, SKP-84, JP-65 and fourteen male parents *viz*; JC-10, RG 1414, DCS 105, SKI 270, 48-1, RG-2275, MCI 8, VI 9, DCS 78, ANDC 8, DCS 107, JC-12, TMV-6, DCS-84 were crossed in LXT design and evaluated along with two hybrid checks as GCH-5 and GCH-7.

The experimental material, consisting 61 entries including 17 parents and their resultant 42 crosses along with two check hybrids, was raised in a randomized block design with three replications over three environments viz., Navsari (E_1), Vyara (E_2) and Achhalia (E_3) during rabi season. Each entry was accommodated in single row of 6 m. length spaced at 120 cm apart with plant-to-plant spacing of 60 cm. Recommended practices and plant protection measures were adopted timely to raise the healthy crop.

Table 1: Geographic and edaphic details of environments (Locations)

Sr. No.	Details	Locations		
		Navsari (E_1)	Vyara (E_2)	Achhalia (E_3)
1.	Latitude	20º – 57' N	21º – 04' N	21º – 77' N
2.	Longitude	72º – 54' E	73º – 03' E	75º – 18' E
3.	Altitude	11.98 m	12.00 m	30.00 m
4.	Soil type	Heavy black and fine textured	Heavy black and fine textured	Alluvial and Medium textured
Location details:				
E_1: College farm, Navsari Agricultural University (N.A.U.), Navsari				
E_2: Regional Rice Research Station, Vyara, N.A.U., Navsari				
E_3: Cotton Research Sub-Station, Achhalia, N.A.U., Navsari				

Five competitive plants from each entry in each replication were randomly selected before flowering and tagged for the purpose of recording observations on different characters (except days to flowering and days to maturity) and their average values were used in the statistical analysis. The observations were recorded on number of capsules on primary spike, 100-seed weight (g), seed yield per plant (g) and oil content (%). The statistical analysis for genotype x environment interaction and stability was carried-out according to the procedure outlined by Eberhart and Russell (1966) [4] for seed yield and its components.

Results and Discussion

The stability analysis (Table 1) indicated the presence of significant G x E interaction for all the characters under study except oil content. A very high proportion of total variance was accounted for the environment (linear) component. This indicated that environments differed significantly and had linear effect. These results are in agreement with the earlier findings of Hirachand *et al.* (1982) [6], Manivel and Hussain (2000) [11], Joshi *et al.* (2002c and d) [7], Kumari *et al.* (2003) [9], Solanki and Joshi (2003) [14] and Patel *et al.* (2010) [12].

The analysis of variance for phenotypic stability revealed that mean squares due to genotypes as well as environments were highly significant for all the characters when tested against pooled error as well as pooled deviation. The mean squares due to environments (linear) were highly significant for all the characters. Higher magnitude of mean squares due to environment (linear) indicated that differences between environments were considerable for all the characters and revealed that these characters were influenced by environments considerably, suggesting thereby that large differences between environments alongwith the greater part of genotypic response was a linear function of environment. These results are in agreement with the earlier findings of Hirachand *et al.* (1982) [6], Manivel and Hussain (2000) [11], Joshi *et al.* (2002c and d) [7], Kumari *et al.* (2003) [9], Solanki and Joshi (2003) [14] and Patel *et al.* (2010) [12].

Both linear and non-linear components of G x E interaction were significant for number of capsules on primary spike, seed yield per plant and 100-seed weight, which suggested that predictable as well as unpredictable components contributed towards differences in stability of different genotypes. Similar findings were obtained for different characters by Thakkar (2002) [15] number of capsules on primary spike, oil content and seed yield per plant. Manivel and Hussain (2000) [11] for number of capsules on primary spike, 100-seed weight and oil content; Solanki and Joshi (2003) [14] for number of capsules on primary spike and 100-seed weight; Madariya *et al.* (2010) [10] for number of capsules on primary spike and 100-seed weight and Patel *et al.* (2011) for number of capsules of primary spike and seed yield per plant. Eberhart and Russell (1966) [4] defined a stable genotype as one, which has a high mean (X), regression coefficient around unity ($b_i \cong 1$) and deviation from regression as small as possible ($S^2d_i \cong 0$).

Number of capsules on primary spike (Table 2)

Among parents, two lines *viz.*, SKP-84 ($\bar{X}$ = 84.84), and VP-1 ($\bar{X}$ = 65.10) and three testers *viz.*, SKI-270 ($\bar{X}$ = 81.30), 48-1 ($\bar{X}$ = 68.73) and ANDC-8 ($\bar{X}$ = 58.44) indicated average stability across environments. Among 29 predictable hybrids, best five hybrids were VP-1 x SKI-270 ($\bar{X}$ = 116.69), SKP-84 x TMV-6 ($\bar{X}$ = 113.25), JP-65 x SKI-270 ($\bar{X}$ = 105.99), SKP-84 x 48-1 ($\bar{X}$ = 105.76) and SKP-84 x DCS-84 ($\bar{X}$ = 102.54). On other hand hybrid SKP-84 x SKI-270 ($\bar{X}$ = 117.92) had the highest number of capsules on primary spike with above average stability. Fifteen hybrids were unstable across environments with significant S^2di, while 12 hybrids had low mean but, adapted to all the environmental conditions with bi ≈ 1 and non-significant S^2di.

Seed yield per plant (g) (Table 2)

A perusal of data revealed that the prediction of performance for seed yield per plant would be possible for all the parents and all the hybrids (except two hybrids) and checks they depicted non-significant deviation from regression.

Among all the parents, 9 parents showed high mean while top five parents *viz.*, SKP-84 ($\bar{X}$ = 173.66), SKI-270 ($\bar{X}$ = 168.52), DCS-84 ($\bar{X}$ = 167.11), 48-1 ($\bar{X}$ = 166.62) and TMV-6 ($\bar{X}$ = 163.19) were average responsive (bi ≈ 1) to all the environmental conditions with higher seed yield per plant. On the other hand, the 8 parents were lower yielding but, possessed average responsiveness (bi ≈ 1) and non-significant deviation from regression (S^2di), thereby showing their adaptability to different environments.

Among the hybrids and checks, 14 hybrids *viz.*, SKP-84 x 270 ($\bar{X}$ =266.87), SKP-84 x TMV-6 ($\bar{X}$ =256.87), VP-1 x SKI-270 ($\bar{X}$ =255.44), SKP-84 x 48-1($\bar{X}$ =251.24), SKP-84 x DCS 84 ($\bar{X}$ =248.01), VP-1 x DCS-78 ($\bar{X}$ =247.24), VP-1 x ANDC-8 ($\bar{X}$ =246.99), SKP-84 x ANDC-8 ($\bar{X}$ =239.51), VP-1 x TMV-6 ($\bar{X}$ =237.62), JP-65 x TMV-6 ($\bar{X}$ =234.49), JP-65 x SKI-270 ($\bar{X}$ =234.15), JP-65 x 48-1 ($\bar{X}$ =216.13), VP-1 x 48-1 ($\bar{X}$ =206.63) and VP-1 x VI-9 ($\bar{X}$ =200.02) and both checks GCH-5 ($\bar{X}$ =217.96) and GCH-7 ($\bar{X}$ =224.00) were high yielder with average responsiveness and adaptability to different environments. Thirty three hybrids showed average responsiveness and stability in all the three environments studied with low seed yield per plant as they exhibited regression coefficient around unity (bi ≈ 1) and non-significant S^2di. The hybrid VP-1 x DCS-84 ($\bar{X}$ =252.12) and SKP-84 X VI-9 ($\bar{X}$ =219.44) had high yield with less than unit regression coefficient (bi < 1) and non-significant deviation from regression, which indicated it's above average stability i.e. responsive to poor environmental condition. Cross combination, JP-65 x DCS-84 ($\bar{X}$ =203.17) and JP-65 x VI-9 ($\bar{X}$ =200.89) proved to be low responder with high stability in favourable environment (higher mean, b_i>1, S^2d_i around unity).

100-seed weight (g) (Table 2)

All the parents (except TMV-6) and hybrids were stable for 100-seed weight, which indicated higher predictability for different parents and hybrids. Among 9 stable parents have high 100-seed weight out of them most stable five parents *viz.*, ANDC-8 ($\bar{X}$ = 35.19), DCS-78 ($\bar{X}$ = 31.21), DCS-84 ($\bar{X}$ = 31.20), 48-1 ($\bar{X}$ = 31.13) and SKP-84 ($\bar{X}$ = 30.92), were average responsive and adaptive to all the environments with high 100-seed weight.

Out of 42 hybrids, 24 hybrids expressed high mean for 100-seed weight. Among these 24 hybrids, best five hybrids *viz.*, SKP-84 x RG-1414 ($\bar{X}$ = 33.99), VP-1 x JC-10 ($\bar{X}$ = 32.97), VP-1 x TMV-6 ($\bar{X}$ = 32.94), JP-65 x DCS-107 ($\bar{X}$ = 32.38) and VP-1 x 2275 ($\bar{X}$ = 32.31), were average stable and responsive to all the environments and four hybrids JP-65 x JC-10 ($\bar{X}$ = 34.51),SKP-84 x JC-12 ($\bar{X}$ = 33.37), SKP-84 x SKI-270 ($\bar{X}$ = 31.19) and SKP-84 x JC-10 ($\bar{X}$ = 34.41) was above average responsive as they depicted less than unit regression coefficient. The cross combination VP-1 x MCI-8 ($\bar{X}$ = 32.28), possessed below average stability which indicated that this hybrid stable in favorable environmental condition. Twenty one hybrids had low mean for 100-seed weight but, possessed average responsiveness (bi ≈ 1) and non-significant deviation from regression (S^2di), thereby showing adaptability to different environments.

Oil content (%) (Table 2)

Prediction of performance was possible for all the parents and hybrids except five and two hybrids. One line JP-65 ($\bar{X}$ = 48.40), was average responsive with high mean, while among the testers, four testers *viz.*, VI-9 ($\bar{X}$ = 49.74), ANDC-8 ($\bar{X}$ = 48.78), MCI-8 ($\bar{X}$ = 48.80) and JC-10 ($\bar{X}$ = 48.35) possessed average responsiveness with high oil content, thereby showing their adaptability to different environments. Line SKP 84 ($\bar{X}$ = 49.02) had high mean and above average response with adaptability to poor environments. Out of 42 stable hybrids (including both checks) 22 hybrids had higher oil content and 20 hybrids had lower oil content with unit regression coefficient and least deviation from regression, indicating their average stable performance across the environments. Out of 22 high oil content hybrids, best five hybrids were SKP-84 x SKI-270 ($\bar{X}$ = 50.51), VP-1 x TMV-6 ($\bar{X}$ = 49.71), JP-65 x RG-1414 ($\bar{X}$ = 49.57), JP-65 x 48-1 ($\bar{X}$ = 49.54) and SKP-84 x JC-12 ($\bar{X}$ = 49.32).

Conclusion

None of the parent or hybrid found to be stable for all the characters over the environments under study. Therefore the best performing parents and top three hybrids were worked out as per character for further utilization in improvement programme of said characters. The parents SKP-84, VP-1, SKI-270, 48-1, ANDC-8 and top three hybrids *viz*; VP-1 x SKI-270, SKP-84 x TMV-6 and JP-65 x SKI-270 were found to be average stable for Number of capsules on primary spike. Likewise, for seed yield per plant SKP-84, SKI-270, DCS-84, 48-1 as parents and SKP-84 x 270, SKP-84 x TMV-6 and VP-1 x SKI-270 as top three hybrids were average responsive. For 100-seed weight, SKP-84, JP-65, ANDC-8, DCS-78, DCS-84 among parents and SKP-84 x RG-1414, VP-1 x JC-10 and VP-1 x TMV-6 were top three stable hybrids. The parents JP-65, VI-9, ANDC-8 and MCI-8 and top three hybrids SKP-84 x SKI-270, VP-1 x TMV-6 and JP-65 x RG-1414 were the best options for oil content on percent basis.

Table 2: Analysis of variance (mean square) of phenotypic stability for different characters in castor

Source of variation	D.F.	Number of capsules on primary spike		Seed yield per plant (g)		100-seed weight (g)		Oil content (%)	
Genotypes	60	1135.73	**++	4474.90	**++	26.96	**++	3.91	**++
Env.+ (Gen. x Env.)	122	64.08	**	41.18	**	5.55	**++	0.94	
Environments	2	792.95	**++	155.73	**+	18.58	**++	4.05	**+
G x E	120	51.94	**	39.02	**+	5.34	**++	0.89	
Environments (Lin.)	1	1585.90	**++	311.47	**++	37.15	**++	8.11	**++
G x E (Lin.)	60	43.37	**	47.03	**+	9.03	**	0.62	
Pooled Deviation	61	59.51	**	30.87		1.62	*	1.14	*
Pooled Error	360	11.47		27.14		3.48		0.75	

*, ** Significant against pooled error M.S. at 5% and 1% levels, respectively.

$^{+}$, $^{++}$ Significant against pooled deviation M.S. at 5% and 1% levels, respectively.

Table 3: Stability parameters for 61 genotypes for number of capsules on primary spike, seed yield per plant (g), 100-seed weight (g) and Oil content (%) in castor

Sr. No.	Genotypes	Number of capsules on primary spike					Seed yield per plant (g)					100-seed weight (g)					Oil content (%)				
		Mean	b_i		S^2di		Mean	b_i		S^2di		Mean	b_i		S^2di		Mean	b_i		S^2di	
1	VP-1	65.10	-1.48		-7.53		143.88	1.09		-26.03		24.87	-0.76		-2.83		45.97	1.46		-0.75	
2	SKP-84	84.84	1.16		21.12		173.66	-0.26		-25.47		30.92	1.02		-1.85		49.02	-2.03	**	-0.75	
3	JP-65	51.40	-1.12	*	-10.88		140.79	0.99		-22.33		30.79	1.57		1.23		48.40	0.03		-0.75	
4	JC-10	44.99	0.66		75.28	**	140.73	3.87		-13.04		30.79	0.34		-2.16		48.35	-0.35		-0.68	
5	RG-1414	45.02	0.62		62.24	*	126.98	-1.06		-8.72		28.48	1.61		-3.07		47.92	4.52		0.84	
6	DCS-105	44.96	0.59		-10.58		125.53	-1.51		36.51		24.87	-0.68		-3.25		47.96	0.85		9.81	**
7	SKI-270	81.30	-0.55		10.51		168.52	4.53		60.41		26.98	0.98		-3.47		49.32	0.84		6.25	**
8	48-1	68.73	0.61		-4.10		166.62	1.84		-25.53		28.54	-1.30		-2.13		47.41	0.03		-0.71	
9	RG-2275	43.67	-1.06		-10.57		118.18	-2.58		14.95		31.13	-1.57		-3.41		48.86	0.33		4.52	**
10	MCI-8	53.25	0.71		53.29	*	146.56	0.64		15.12		26.74	0.49		-3.04		48.80	7.37		-0.44	
11	VI-9	50.32	0.86		52.89	*	151.03	2.35		63.74		18.45	1.52		-3.46		49.74	-3.98		-0.64	
12	DCS-78	53.14	1.52		145.24	**	161.58	4.05		-19.70		31.21	0.27		-2.52		48.56	-3.67		5.41	**
13	ANDC-8	58.44	0.67		-10.51		152.60	7.89		-16.33		35.19	1.75		-3.47		48.78	1.32		-0.64	
14	DCS-107	45.83	-0.56		46.77	*	138.48	3.26		24.29		24.47	-1.20	*	-3.47		49.66	1.07		5.44	**
15	JC-12	49.25	-1.59	**	-11.47		154.99	3.68		-22.52		24.08	0.59		0.81		47.94	5.77		-0.64	
16	TMV-6	75.97	0.88		98.27	**	163.19	1.58		-27.06		32.53	-1.05		18.60	*	48.09	-2.90		-0.64	
17	DCS-84	56.33	-1.69		48.07	*	167.11	-3.29		-23.35		31.20	1.16		-0.62		46.20	0.08		-0.64	
	Parents Mean	57.21					149.44					28.31					48.29				
18	VP-1 X JC-10	64.47	0.01		-3.79		154.27	-1.06	*	-27.13		32.97	-1.60		-2.59		48.71	-0.85		-0.57	
19	VP-1 X RG-1414	55.80	0.23		142.34	**	165.39	0.84		25.73		30.15	-2.64	*	-3.45		47.47	1.09		-0.74	
20	VP-1 X DCS-105	68.73	2.27		14.00		176.72	-0.21		0.16		29.72	-0.48		0.04		47.43	3.12		4.96	**
21	VP-1 X SKI-270	116.69	1.14		-11.38		255.44	-0.61		-27.01		29.44	-0.65	*	-3.48		47.42	3.25		0.23	
22	VP-1 X 48-1	91.24	0.14		-7.89		206.63	0.44		-21.92		25.09	0.76		-3.45		48.93	-1.77		-0.54	
23	VP-1 X RG-2275	67.54	2.30		169.78	**	149.08	-2.47		70.53		32.31	0.86		-3.02		49.17	0.83		0.65	
24	VP-1 X MCI-8	72.37	0.17		11.38		193.99	7.53		-25.46		32.28	1.33		-1.37		48.16	1.93		-0.75	
25	VP-1 X VI-9	87.37	0.42		10.52		200.02	0.68		4.25		31.04	2.52		-1.51		47.44	3.11		-0.60	
26	VP-1 X DCS-78	68.27	0.72		224.46	**	247.24	-0.49		-19.84		26.82	3.46		-3.40		47.64	1.67		-0.11	
27	VP-1 X ANDC-8	92.04	1.31		2.18		246.99	-0.32		-24.28		27.72	3.82		-2.94		47.97	0.76		-0.44	
28	VP-1 X DCS-107	55.10	2.36		25.48		155.51	-1.80		-12.58		25.37	-0.10		-1.30		47.90	3.63		-0.75	
29	VP-1 X JC-12	61.54	1.14		3.59		155.48	2.97		-24.78		32.03	-0.70		-0.90		48.31	1.75		-0.75	
30	VP-1 X TMV-6	88.63	2.41		0.26		237.62	-0.47		-26.12		32.94	1.21		-1.50		49.71	-1.33		1.16	
31	VP-1 X DCS-84	93.06	1.49		13.73		252.12	-1.76		24.97		29.56	-0.10		-0.57		49.20	0.66		-0.75	
32	SKP-84 X JC-10	63.08	1.11		30.61		163.39	1.40		-20.15		34.41	-4.15	*	-3.47		48.14	1.83		-0.07	
33	SKP-84 X RG-1414	60.75	2.29		96.89	**	158.82	-1.87		-6.26		33.99	-2.26		0.37		49.13	1.39		-0.75	
34	SKP-84 X DCS-105	80.50	3.39		51.05	*	174.98	-0.57		-20.67		30.92	6.79		-2.67		47.92	2.48		-0.21	
35	SKP-84 X SKI-270	117.92	-1.42	*	-11.29		266.87	2.06		37.21		31.19	-2.01	**	-3.48		50.51	1.96		-0.07	
36	SKP-84 X 48-1	105.76	-0.13		-6.26		251.24	-0.79		-23.66		32.19	-6.36		-0.41		48.85	-0.88		0.75	
37	SKP-84 X RG-2275	63.91	1.00		-10.23		196.41	-3.34		14.59		31.35	-4.69		2.22		49.74	-0.55		0.08	
38	SKP-84 X MCI-8	84.55	-1.15		-8.98		193.70	0.89		101.90	*	29.01	-1.32		-2.07		49.84	4.07		-0.73	
39	SKP-84 X VI-9	91.21	1.26		-5.25		219.44	-1.54	*	-23.52		29.51	-2.61		-2.73		49.21	-1.04		-0.63	
40	SKP-84 X DCS-78	84.69	-0.01		615.56	**	196.22	3.93		60.42		27.89	-2.93		-2.38		46.74	1.75		0.55	
41	SKP-84 X ANDC-8	101.16	1.94		5.07		239.51	2.22		49.83		26.30	6.62		-2.95		48.59	2.16		-0.51	
42	SKP-84 X DCS-107	59.45	2.12		-2.72		170.36	1.51		-27.13		31.09	-3.11		-2.48		49.14	0.73		-0.75	
43	SKP-84 X JC-12	65.50	1.26		39.75	*	163.82	0.77		-14.99		33.37	-4.67	*	-3.45		49.32	0.07		-0.75	
44	SKP-84 X TMV-6	113.25	1.62		-5.58		256.87	1.70		-13.85		32.18	-4.19		-2.65		47.26	1.50		-0.27	
45	SKP-84 X DCS-84	102.54	0.39		-7.52		248.01	1.90		-12.08		30.76	0.35		-3.30		49.63	-0.29		-0.22	
46	JP-65 X JC-10	61.05	2.36		70.92	**	168.83	-0.75		-16.40		34.51	-5.76	*	-3.46		46.98	2.45		-0.05	
47	JP-65 X RG-1414	58.61	1.20		32.46		160.32	1.99		-25.67		31.43	3.51		0.81		49.57	0.24		-0.67	
48	JP-65 X DCS-105	76.41	2.50		35.58	*	197.57	2.89		-27.08		28.71	-0.43		-1.96		45.07	0.37		-0.08	
49	JP-65 X SKI-270	105.99	1.44		-0.50		234.15	-1.68		54.67		31.10	1.66		-3.06		48.74	-0.23		-0.74	
50	JP-65 X 48-1	67.66	2.79		160.75	**	216.31	-4.17		49.51		28.21	10.75		0.75		49.54	0.06		-0.14	
51	JP-65 X RG-2275	61.36	2.17		25.08		160.64	1.73		-26.85		29.79	3.01		-1.30		48.72	0.76		-0.06	
52	JP-65 X MCI-8	74.83	3.28		33.92	*	167.81	3.03		-19.87		30.70	4.84		-3.15		49.21	1.32		-0.73	
53	JP-65 X VI-9	80.73	1.23		123.41	**	200.89	10.5	*	25.47		30.36	3.98		-3.33		45.88	1.41		-0.69	
54	JP-65 X DCS-78	69.28	2.54		80.88	**	180.31	-2.76		225.94	**	27.06	10.79		-2.08		47.26	7.44		-0.04	
55	JP-65 X ANDC-8	77.01	3.36		239.11	**	191.31	-2.53		67.64		28.28	6.41		-3.45		48.77	1.05		-0.75	
56	JP-65 X DCS-107	60.65	1.33		28.99		153.06	-1.94		9.91		32.38	8.19		-3.10		46.21	-1.98		1.83	
57	JP-65 X JC-12	59.55	2.10		20.88		159.19	2.04		-26.80		30.63	6.03		-2.96		47.67	1.75		0.26	
58	JP-65 X TMV-6	97.66	3.06		159.00	**	234.49	-1.94		-25.88		30.04	-0.70		-0.55		46.41	1.05		1.79	
59	JP-65 X DCS-84	91.50	1.95		15.16		203.17	9.85	*	26.02		28.44	6.25		-2.89		46.76	1.95		2.72	*
60	GCH-5 (C)	92.57	-0.15		-10.13		217.96	4.61		-25.76		31.87	5.96		-2.17		47.73	0.50		-0.75	
61	GCH-7 (C)	91.04	-0.12		-9.48		224.00	2.83		-12.70		30.86	0.32		-2.37		48.13	-0.91		-0.73	
	Cross Mean	79.61					199.23					30.36					48.23				

* and ** significant at 5% and 1% level of probability, respectively.

References

1. Allard RW. Principles of Plant Breeding. John Wiley & Sons Inc., New York; c1960.
2. Allard RW, Bradshaw AD. Implications of genotype-environmental interaction in applied plant breeding. Crop Sci. 1964;4(6):503-508.
3. Anon; c2020. https://eands.dacnet.nic.in/APY_96_To_06.htm
4. Eberhart SA, Russell WA. Stability parameters for comparing the varieties. Crop Sci. 1966;6(1):36-40.
5. Finlay KW, Wilkinson GN. The analysis of adaptation in a plant breeding programme. Aust. J Agric. Sci. 1963;14:742-754.
6. Hirachand Joshi HJ, Dholaria SJ, Patel PK. Stability parameters for hybrid castor. Indian J Agric. Sci. 1982;52(4):222-224.
7. Joshi HJ, Mehta DR, Jadon BS. Genotype and environment interaction for yield and yield components in castor (*Ricinus communis* L.). Adv. Plant Sci. 2002c;15(1):261-266.
8. Joshi HJ, Mehta DR, Jadon BS. Phenotypic stability and adaptability of castor hybrids. Indian J Agric. Res. 2002d;36(4):269-273.
9. Kumari TR, Subramanyam D, Shreedhar M. Stability analysis in castor. Crop Res. 2003;25(1):96-102.
10. Madariya RB, Chovatia VP, Kavani RH, Barad VG, Padhar PR. 2010, Phenotypic stability in castor (*Ricinus communis* L.). J Oilseeds Res. 2003;27:27-30.
11. Manivel P, Hussain HSJ. Genotype x environment interaction in castor. Madras Agric. J. 2000;87(7-9):394-397.
12. Patel JA, Patel BN, Patel AR, Rajiv K. Genotype × environment interaction and stability parameters for yield and component characters in castor (*Ricinus communis* L.). J. Oilseeds Res. 2010;2:47-49.
13. Perkins JM, Jinks JL. Environmental and genotype-environmental components of variability III. Multiple lines and crosses. Heredity. 1968;23:339-356.
14. Solanki SS, Joshi P. Phenotypic stability of hybrids and parents for seed yield and its components in castor. J Oilseeds Res. 2003;20(1):45-47.
15. Thakkar DA. Heterosis and combining ability studies in castor (*Ricinus communis* L.). Ph.D. Thesis (Unpublished), submitted to Gujarat Agricultural University, Sardarkrushinagar; c2002.