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Research Article

Genotype x Environment interaction and stability analysis for seed yield and sex attributing traits in castor (*Ricinus communis* L.)

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Abstract

The present study was conducted to assess the existence of genotype x environmental (G X E) interactions and stability for sex related traits in castor using 16 genotypes under three artificially created environments over three locations in Kharif 2012. Pooled Analysis of variance over three environments revealed the genotypic variances were highly significant for all the sex related characters which indicated considerable genetic variability in the population. Stability parameters for sex expression revealed that for per cent pistillate whorls on primary raceme the genotypes VP 1, JP 65, SKP 84 and JI 35 were found better under poor environments. The female parents VP 1, JP 65 and SKP 84 showed stable and consistent performance in all order of spikes whereas, the male parent 48-1 had above average response and high stability in better environments for per cent pistillate whorls on secondary raceme only. Thus, parental lines VP 1, JP 65, SKP 84 and JI 35 may be utilized in hybrid breeding programme to exploit their consistent performance for sex expression in all order of spike.

Key words

Stability analysis, G x E interaction, sex expression

Introduction

Castor [*Ricinus communis* (L.)] is an important non-edible oil seed crop of arid and semi-arid regions of India, which belongs to the genus *Ricinus* of Euphorbiaceae family. The castor possess 2n = 20 chromosome number. Its monoecious nature favours cross-pollination up to the extent of 50 per cent. The crop has cultivated in many tropical and subtropical regions of the world (Govaerts *et al*., 2000). The release of first hybrid GCH-3 based on exotic pistillate line TSP-10R in Gujarat during year 1968 attracted the attention of breeders to utilize the heterosis on commercial scale. Subsequently, heterosis breeding programme was geared up in Gujarat and as a result, seven hybrids namely GCH-3 (1968), GAUCH-1 (1973), GCH-2 (1983), GCH-4 (1986), GCH -5 (1995), GCH-6 (1999) and GCH-7 (2006) were released periodically for commercial cultivation with a yield potential of over 5 tones/ha under irrigated conditions which based on versatile pistillate lines VP-1 and SKP-84 possesses S-type female sex mechanism. Unlike the conventional method, seed production in the refined method should be taken up either in summer/kharif season. In addition, high temperature coupled with lack of irrigation facilities and desiccating winds reduced the seed yield of pistillate lines.

A phenotype is a result of interplay of genotype and its environment. A particular genotype does not exhibit the same phenotypic characteristics under different environments and different genotype response differently to a particular environment. The crop yield is dependent on the genotype, the environment and their interaction. When interaction between genotype and environment is present, ranking of genotype will be different under different environments. The plant breeder is always interested in the stability of performance for the characters which are of economically important. The desirable hybrids should have low genotype x environment interactions for important characters, so as to get desirable performance of hybrids over wide range of environmental conditions. Such hybrids are said to be stable because of their stable performance under changing environments. Genotype x environment interactions are of common occurrence and often creates manifold difficulties in interpreting results and thus hamper the progress of breeding programmes aiming at further genetic improvement in crop plants. Hence, the knowledge of magnitude and nature of genotype x environment interaction is very useful to plant breeder.

Materials and methods

The experimental materials consisted of sixteen genotypes of castor *viz*., VP 1, Geeta, JP 65, SKP 84, VI 9, JI 35, 48 1, SH 72, JI 96, SKI 215 ,GAUCH 1, GCH 2, GCH 4, GCH 5, GCH 6 and GCH 7. The field experiment was conducted at Main Castor and Mustard Research Station , Centre for Watershed management, participatory research and rural engineering, Sardarkrushinagar Dantiwada Agricultural University during *kharif* (2012-13) with spacing of 90 X 60 cm in rainfed condition and 120 X 60 cm in irrigated condition, respectively. Experiment was laid out in randomized complete block design replicated thrice. The detail of location and date of sowing are depicted in Table 1. The sex related characters *viz*., per cent pistillate whorls on primary raceme, per cent pistillate whorls on secondary raceme and per cent pistillate whorls on tertiary raceme were included for the study. Analysis of variance was performed and stability parameters were computed following the model proposed by Eberhart and Russell (1966). The type of stability was decided on regression coefficient (b_i) and mean values (Finaly and Wilkinson 1963).

Results and discussion

The analysis of variance for individual environments revealed highly significant mean squares due to genotypes for all the characters indicating the presence of genetic variation for different characters in the population (Table 2). Pooled analysis of variance revealed that the genotypic variances were highly significant for all the characters. The environmental variance was highly significant for all the characters studied indicating difference in the environments selected for the study. The variance due to G x E interaction was also highly significant for all the traits (Table 3).

The analysis of variance for stability of different characters, as per Eberhart and Russell (1966) model is given in Table 4. The mean squares due to genotypes, environments, genotype x environment, environment (linear) and genotype x environment (linear) were tested against pooled deviation. The pooled deviation was tested against pooled error. The significant mean sum of squares due to genotypes, environments and environment (linear) for all characters were observed when tested against pooled deviation.

The mean squares due to G x E interactions were significant for per cent pistillate whorls on primary raceme, per cent pistillate whorls on secondary raceme and per cent pistillate whorls on tertiary raceme, which indicated differential response of genotypes in varying environment for these traits. The mean sum of square due to environment and environment (linear) were found highly significant for all the characters (Table 4), which revealed that differences due to environments were real and thus, the creation of environments was fully justified.

Stability parameters analysis for seed yield per plant revealed that thirteen genotypes (GAUCH 1, GCH 2, GCH 4, GCH 6, GCH 7, VP 1, Geeta, JI 65, SKP 84, JI 35, 48-1, SH 72 and JI 96) showed non-significant deviation from regression. For regression coefficient, ten genotypes showed non-significant unity for regression (Table 5). The nine genotypes *viz*., GCH 2, GCH 4, GCH 5, GCH 6, GCH 7, Geeta, 48-1, SH 72 and JI 96 depicted above average performance. Among these, five genotypes *viz*., GCH 4, GCH 6, GCH 7, Geeta and 48-1 exhibited unit regression (b_i) and non-significant deviation from regression (S^2d_i). Two genotypes *viz*., GCH 2 and JI 96 depicted significant regression coefficient ($b_i > 1$) and non-significant deviation from regression (S^2d_i). Based on higher mean performance, unit regression and least deviation from regression, five genotypes were found stable under varying environments. The genotypes GCH 4, GCH 6, GCH 7, Geeta and 48-1 were found to be ideally stable for seed yield per plant. Genotypes *viz*., GCH 2, GCH 4, GCH 7, Geeta, 48-1 and JI 96 registered higher mean of seed yield per plant, non-significant deviation from linear regression (S^2d_i) and regression coefficient greater than one ($b_i > 1$). Therefore, these genotypes were considered as better for favourable environments. Two genotypes (GCH 6 and SH 72) had higher mean, non-significant deviation from linear regression (S^2d_i) and regression coefficient less than one ($b_i < 1$) (Table 5). Therefore, these genotypes were considered as ideal genotypes for poor environments. These results were in accordance with the reports of Manivel and Hussain (2001), Joshi *et al*. (2002), Kumari *et al*. (2003), Thakkar *et al*. (2010) and Sodavadiya and Dhaduk (2011).

The stability parameters for per cent pistillate whorls on primary raceme revealed that VP 1, JP 65 and SKP 84 registered higher mean, non-significant deviation from linear regression (S^2d_i) and regression coefficient less than one ($b_i < 1$). Therefore, they were better under poor environments. Two genotypes (GCH 5 and 48-1) registered higher per cent pistillate whorls on primary raceme, non-significant deviation from linear regression and $b_i > 1$ (Table 5), considering suitabily under favourable environments. Similar findings were reported by Solanki and Joshi (2000), whereas, contradictory results were obtained by Murthy *et al*. (2003).

The stability analysis for per cent pistillate whorls on secondary raceme revealed that the genotypes VP 1, JP 65 and SKP 84 recorded higher mean, regression coefficient approaching unity and non-significant deviation from regression. Therefore,

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these genotypes were considered suitable under poor environments. The genotypes 48-1 and SKI 215 had above average response and high stability in better environments as is evident from their significant linear regression (b_i> 1) and non-significant deviation from regression (S^2d_i) (Table 5). Similar results were reported by Solanki and Joshi (2000), whereas, contradictory result was found by Murthy *et al*. (2003).

For per cent pistillate whorls on tertiary raceme based on unit regression and least deviation from regression, three genotypes VP 1, JP 65 and SKP 84 were found to be ideally stable for per cent pistillate whorls on tertiary raceme. The genotype 48-1 expressed higher mean, non- significant deviation from linear regression (S^2d_i) and regression coefficient greater than one (b_i> 1) (Table 5). Therefore, this genotype was considered as better for favourable environments. The genotypes VP 1, JP 65 and SKP 84 had higher mean, non-significant S^2d_i and regression coefficient less than one (b_i< 1). Thus, these genotypes could be considered as better under poor environments. These results were in accordance as reported by Solanki and Joshi (2000), whereas, contradictory results were observed by Murthy *et al*. (2003).

Based on stability parameters for sex expression related traits, it could be summarized that the pistillate lines VP 1, JP 65 and SKP 84 consistently expressed stable performance in all orders of racemes under poor environments, whereas, male parental line 48-1 found ideally stable for better environment (Table 6). These lines may be used as parental lines in further breeding programme of hybridization.

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Table 1. Details of environments

Sl. No.	Location	Environments	Date of sowing
1.	Centre for Watershed management, participatory research and rural engineering, S. D. Agricultural University, Sardarkrushinagar (Rainfed)	E-I	16th July 2012
2.	Main Castor and Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar (Early sown irrigated)	E-II	18th July 2012
3.	Main Castor and Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar (Late sown irrigated)	E-III	20st August 2012

Table 2. Analysis of variance (Mean square) for individual environment

Sources of variation	d.f	Seed yield per plant (g)	Per cent pistillate whorls on primary raceme (ASN)	Per cent pistillate whorls on secondary raceme (ASN)	Per cent pistillate whorls on tertiary raceme (ASN)
			ENVIRONMENT – I		
Replication	2	4.53	51.96	10.95	128.90
Genotype	15	1729.20**	420.55**	601.57**	686.95**
Error	30	36.02	24.31	42.77	53.08
			ENVIRONMENT – II		
Replication	2	338.00	311.05**	182.11	13.36
Genotype	15	10298.88**	358.94**	446.56**	625.47**
Error	30	140.73	54.99	74.51	59.69
			ENVIRONMENT – III		
Replication	2	103.73	3.52	37.30	97.89
Genotype	15	11624.61**	549.00**	692.45**	648.20**
Error	30	220.27	24.48	30.81	46.94

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

Table 3. Pooled analysis of variance (mean square) over environment for different characters in castor.

Sources of variation	d.f	Seed yield per plant (g)	Per cent pistillate whorls on primary raceme (ASN)	Per cent pistillate whorls on secondary raceme (ASN)	Per cent pistillate whorls on tertiary raceme (ASN)
Genotype	15	14763.14**	1027.12**	1397.84**	1648.46**
Environment	2	217141.70**	641.31**	312.88**	871.44**
G x E	30	4444.77**	150.70**	171.37**	156.09**
Pooled error	90	132.34	34.59	49.36	53.23

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

Table 4. Analysis of Variance (mean squares) for stability for various traits in castor

Sources of variation	d.f	Seed yield per plant (g)	Per cent pistillate whorls on primary raceme(ASN)	Per cent pistillate whorls on secondary raceme(ASN)	Per cent pistillate whorls on tertiary raceme(ASN)
Genotype	15	4921.05**	342.38**	465.93**	549.48**
Environment	2	72380.67**	213.79**	104.34*	290.46**
G x E	30	1481.58**	50.23*	57.13**	52.03*
E + (G x E)	32	5912.77**	60.45**	60.08**	66.93**
Environment (Linear)	1	144761.11**	427.59**	208.68**	580.91**
Genotype x Environment (Linear)	15	2544.43**	78.60**	93.21**	82.46**
Pooled deviation	16	392.58**	20.49	19.73	20.24
Pooled error	90	132.34	34.59	49.36	53.23

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

Table 5. Stability parameters for different traits in different genotypes of castor

Sr. No.	Genotypes	Seed yield per plant (g)			Per cent pistillate whorls on primary raceme			Per cent pistillate whorls on secondary raceme			Per cent pistillate whorls on tertiary raceme		
		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.	GAUCH 1	124.07	0.87	-35.57	69.45 (87.18)	-0.77	2.08	67.89 (83.73)	-3.47**	5.21	63.23 (77.31)	-1.63**	53.58
2.	GCH 2	201.23	1.74**	45.98	71.30 (88.98)	-0.25	16.57	67.21 (82.76)	0.70	22.32	64.09 (78.18)	0.80	42.89
3.	GCH 4	155.37	1.14	-23.50	65.57 (80.96)	0.89	12.55	59.95 (72.40)	0.85	75.01	56.88 (69.76)	0.94	-16.93
4.	GCH 5	228.63	2.17	500.19*	73.97 (88.51)	3.18*	-7.82	65.95 (79.04)	4.53*	77.83	62.54 (75.31)	3.34**	-17.64
5.	GCH 6	180.41	0.64	-43.86	65.70 (82.87)	0.53	-8.57	57.38 (70.73)	-1.16	-5.05	52.31 (62.53)	0.30	-16.84
6.	GCH 7	189.27	1.18	-24.18	64.68 (79.04)	2.92*	-4.74	59.26 (72.64)	3.65*	-16.39	52.47 (62.71)	1.26	-17.72
7.	VP 1	77.57	0.26**	2.50	90.00 (100.00)	-0.00	-11.53	90.00 (100.00)	-0.00	-16.45	90.00 (100.00)	-0.00	-17.75
8.	GEETA	173.27	1.42	-8.63	66.38 (83.49)	0.36	-4.72	67.26 (83.11)	-1.84*	-13.84	77.42 (89.82)	1.43	15.99
9.	JP 65	125.11	0.77	-24.15	87.95 (98.89)	0.94	-10.11	90.00 (100.00)	-0.00	-16.45	90.00 (100.00)	-0.00	-17.75
10.	SKP 84	89.33	0.36**	-25.02	90.00 (100.00)	-0.00	-11.53	90.00 (100.00)	-0.00	-16.45	90.00 (100.00)	-0.00	-17.75
11.	VI 9	122.59	0.32**	-44.10**	59.38 (73.87)	-0.67	-11.43	57.41 (70.84)	-1.08	-15.63	59.83 (74.58)	-0.05	-12.71
12.	JI 35	132.10	1.01	-22.38	83.14 (95.47)	-1.12*	97.38	67.89 (85.00)	0.89	5.30	74.25 (90.62)	0.44	23.58
13.	48-1	169.28	1.10	-20.11	81.15 (93.29)	4.07**	15.07	76.70 (90.13)	5.77**	-15.98	74.14 (87.11)	3.66**	11.29
14.	SH 72	161.49	0.54*	-44.12	71.43 (87.82)	0.84	-9.61	60.90 (76.02)	0.90	-15.82	61.65 (76.89)	1.32	-16.60
15.	JI 96	175.27	1.50*	2.25	56.72 (69.47)	0.68	60.33	49.10 (57.02)	0.32	-5.21	50.29 (59.13)	0.23	-17.36
16.	SKI 215	129.91	0.97	5340.23**	80.46 (92.16)	4.39**	19.39	73.75 (86.42)	5.94**	4.06	73.63 (85.73)	3.96**	61.64
	Mean	152.18			73.58 (87.62)			68.79 (81.87)			68.30 (80.61)		
	S.Em. ±	14.01			3.20 (3.35)			3.14 (3.40)			3.18 (3.45)		

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** Significant at P = 0.01; * Significant at P = 0.05; ASN = Arcsine transformed value, Figure in parenthesis are mean over environments

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Table 6. Performance of promising parents and hybrids for stability of sex expression in castor

Genotypes	Per cent pistillate whorls on primary raceme	Per cent pistillate whorls on secondary raceme	Per cent pistillate whorls on tertiary raceme
GAUCH 1	US	US	US
GCH 2	US	US	US
GCH 4	US	US	US
GCH 5	S	US	US
GCH 6	US	US	US
GCH 7	US	US	US
VP 1	S	S	S
GEETA	US	US	US
JP 65	S	S	S
SKP 84	S	S	S
VI 9	US	US	US
JI 35	US	US	US
48-1	S	S	S
SH 72	US	US	US
JI 96	US	US	US
SKI 215	US	S	US

S = Stable; US = Unstable