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Research Article

Genotype x Environment interaction for yield and yield components in sesame (*Sesamum indicum* L.)

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Abstract
A total of 50 hybrids developed by crossing five lines with ten testers were evaluated along with 15 parents and two checks at three different locations in south Gujarat for the assessment of stability in seed yield per plant and yield contributing traits. Three crosses viz.,G.Til-3 x AKT-101, Patan-64 x JLS-110-12 and G.Til-1 x JLT-7 along with five parents and one check G.Til-4 exhibited higher mean seed yield, unit regression (b_i) and least deviation from regression (S^2d_i) and therefore they were classified as stable with average response to environments. Five crosses expressed specific adaptability for favorable environments, while the hybrid G.Til-3 x JLS-110-12 showed specific adaptability to poor environments for seed yield per plant. The stable crosses maintained their yield advantage across environments by maintaining stable performance with respect to two or more important yield components.

Key words:
Sesame, GxE interaction, seed yield per plant, capsules per plant

Introduction

Sesame (*Sesamum indicum* L.) is an ancient and important oilseed crop. It is described as the “Queen of oilseeds” because of its high oil (38-54%), protein (18-25%), calcium, phosphorous, oxalic acid contents and excellent qualities of the seed oil and meal. Sesame seed oil with 85% unsaturated fatty acids is highly stable and has reducing effect on cholesterol. This crop is cultivated in almost all parts of the country as sole or mixed crop during *kharif, semi-rabi*, *rabi* and *summer* seasons and raised in an area of 17.06 lakh hectares with an annual production of 6.85 lakh tones and productivity of 402 kg/ha, (Anonymous, 2014). Several high yielding genotypes of sesame are being developed through breeding efforts. However, most of them are showing inconsistency in seed yield over seasons, years and location, due to high genotype x environment interaction. Larger genotype x environment interaction reduces the progress of selection (Comstock and Moll, 1963). To reduce the effect of genotype-environment interaction, selection of stable genotypes that interact least with the environment is advisable to attain consistent yield. Thus, screening genotypes possessing buffering capacity under varying environmental condition has became an essential part of breeding programme. Lewis (1954) introduced the term ‘stability factor’ to measure the phenotypic stability. According to him, greater the deviation of stability factor from unity, lesser the phenotypic stability. Other stability indices include Wrick’s (1962) ecovalence, Shukla’s (1972) stability variance and Perkins and Jinks (1968) regression coefficient. Finlay and Wilkinson (1963) considered regression coefficient and mean performance of genotypes as a useful criteria to measure the phenotypic stability. In addition to the above two parameters, deviation from the regression is used to characterize a stable genotype (Eberhart and Russel,1966). With this background of various stability parameters, the present investigation was attempted to study the stability of 67 sesamum genotypes (including parents and crosses) for seed yield and component traits under different environmental conditions.

Material and methods

The present study on sesame was conducted at Department of Genetics and Plant Breeding, N.M.College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). Five lines *viz.*, Gujarat Til-1, Gujarat Til-2, Gujarat Til-3, Phule Til No.1, Patan-64 and ten testers *viz.*, JLT-7, JLS-116, JLS-206-10, JLS-110-12, JLS-9707-2, JLT-408, JLT-408-2, AKT-64, PKV-NT-11 and AKT-101, with varying morphological and agronomic characters were collected from diverse locations of Gujarat and Maharashtra state. The selected parents were crossed in line x tester mating design during *rabi* 2011 to produce 50 hybrids. The resulting 50 hybrids along with 15 parents and two check varieties Gujarat Til-4 and TKG-22 were evaluated at three different locations in south Gujarat *viz.*, College farm, NAU,Navsari, Agril. Research Station, Acchaliya and Regional Rice Research Station, Vyara during *rabi* 2012-13 in randomized block design (RBD) with three replications. Recommended package of practices were followed to raise a healthy crop to tap the full genetic potential of the genotypes. Observations were recorded in five randomly selected plants in each entry for seed yield per plant (g), capsules per plant, capsule length (cm), seeds per capsule and 1000 seed weight (g). A combined analysis of variance was used to determine the genotype x environment interaction. Stability parameters were calculated according to the procedure described by Eberhart and Russel (1966).

Results and discussion

Combined Analysis of Variance over seasons for seed yield and component characters is presented in Table 1. Mean squares due to genotypes, environments were significant when tested against pooled error and pooled deviation , while mean square due to G X E interaction was significant against pooled error only. It indicates the presence of substantial variation in the *per se* performance of all the 67 genotypes over environments and in the environmental means over test genotypes. Significant G X E interaction expresses differential performance of genotypes under different environments studied. Highly significant mean squares due to environment (linear) signifies unit change in environmental index for every unit change in the environmental conditions. On the other hand, significant pooled deviation suggests that mean seed yield of genotypes fluctuated significantly from their respective linear path in response to environments. The mean seed yield of 17 parents and checks across locations ranged from 4.01 (Gujarat Til -1) to 5.91 (JLS-110-12) g/plant, While the mean seed yield of 50 crosses ranged from 3.91(PT-1 x JLT-408-2) to 10.09 (GT-3 x AKT-64) g/plant and the grand mean seed yield was 6.25 g/plant (Table 2).

Analysis of the stability parameters for different genotypes (5 females, 10 males, 50 crosses and 2 checks), revealed that none of the genotype was stable for all the traits. Twenty crosses and nine parents displayed higher mean yield than the mean of respective groups (6.62 for hybrids and 5.15 g for parents and checks) in respect of seed yield. Among these genotypes, three crosses *viz.*, G.Til-1 x JLT-7, G.Til-3 x AKT-101 and Patan-64 x JLS-110-12 exhibited higher means, unit regression (b_i) and least deviation from regression (S^2d_i) and therefore they were classified as stable with average response to environments. Further, the cross G.Til-3 x AKT-101 recorded highest seed yield per plant than the rest. Stability parameters also revealed 5 parents *viz.*, JLT-7, JLS-110-12, JLS-9707-2, JLT-408-2, AKT-64 along with check G.Til-4 recorded average response over the environments. The top three parents exhibited high stability were JLS-110-12, JLS-9707-2 and AKT-64. Stable genotypes of sesame based on seed yield per plant was already reported by Mekonnen and Mohammed (2009) and Kumaresan and Nadarajan (2005). In addition to these stable genotypes, five crosses registered specific adaptability for favorable environments, while only one cross, G.Til-3 x JLS-110-12 showed specific adaptability to poor environments for seed yield per plant (Table 3).

Further, none of the parents was found to be suitable for specific environment with respect to seed yield. In general, the female and male parents behaved differently in different environments as observed by Kumaresan and Nadarajan (2005). However, it was noticed that male parent, Phule Til No.1 exhibited above average stability for one or more yield attributing traits like capsules per plant and capsule length coupled with high mean seed yield, which depicted its specific adaptability to unfavorable environments. The only parent JLT-408-2 was stable for yield and important yield components. This parent could be used in recombination breeding programme for yield enhancement. Instances where a few true breeding varieties were comparable in yield to heterozygous crosses under favorable environmental conditions have been reported by (Desai,1996; Kumaresan and Nadarajan,2005). The stability parameters for component traits revealed that several genotypes turned out to be stable for capsules per plant (15), capsule length (20), seeds per capsule (16) and 1000-seed weight (12) (Table 4). Stability of sesame genotypes for most of the yield contributing traits were also observed by Thirugnana Kumar and Praveen Sampath Kumar (2004).

Further, assessment of stability parameters across yield attributes revealed that the crosses G.Til-2 x JLS-110-12 and G.Til-3 x AKT-64 were found to be ideal for better management conditions while none of the cross or parent was suitable for poor management conditions. It was observed that specific adaptability to favorable and unfavorable environments was exhibited by several genotypes for capsules per plant (3 and 1), capsule length (4 and 3), seeds per capsule (5 and 4) and 1000-seed weight (4 each), respectively. The genotypes which are specifically adapted to better or poor environments are due to adaptive plasticity or individual adaptability. The genotype may express different phenotypes in different environments, each of which being better adapted for the particular situation. This type of behavior has been regarded as adaptive plasticity (Mather, 1943), individual adaptability (Cook and Johnson, 1968) and individual buffering (Allard and Bradshaw, 1964).

According to Graffius (1956) stability of seed yield is the reflection of stability of various yield components. These stable crosses (G.Til-3 x AKT-101,Patan-64 x JLS-110-12 and G.Til-1 x JLT-7) maintained a yield advantage across environments by maintaining stable performance regarding two or more important yield components such as capsules per plant, capsule length, seeds per capsule and 1000-seed weight. This evidence suggested that consistent performance of yield components is crucial for seed yield stability in sesamum across diverse environments. These stable parents and crosses can be recommended for cultivation over wide range locations in south Gujarat.

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Table 1. Analysis of variance (mean squares) for different characters in sesamum.

Source of variation	D.F.	Seed yield per plant (g)	Capsules per plant	Length of capsule (cm)	Seeds per capsule	1000-seed weight (g)
Genotypes	66	5.89 ** ++	110.34 ** ++	0.063 ** ++	70.68 ** ++	0.140 ** ++
Env.+ (Gen. x Env.)	134	0.81 ** ++	41.22 ** ++	0.011 **	18.45 **	0.066 ** ++
Environments	2	23.56 ** ++	1474.75 ** ++	0.112 ** ++	437.48 ** ++	2.001 ** ++
G x E	132	0.46 **	19.49 **	0.010 **	12.10 **	0.037 **
Environments (Lin.)	1	47.11 ** ++	2949.50 ** ++	0.223 ** ++	874.96 ** ++	4.002 ** ++
G x E (Lin.)	66	0.50 **	17.10 **	0.010 **	10.60 **	0.037 **
Pooled Deviation	67	0.42 ** ++	21.55 ** ++	0.010 ** ++	13.40 ** ++	0.037 ** ++
Pooled Error	396	0.08	3.61	0.005	5.12	0.005

*, ** : 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 2. Estimates of stability parameters for seed yield (g/plant) in sesamum.

Sr. No.	Genotypes	Mean yield (g/plant)	b_i	S^2di
1	GT-1 x JLT-7	6.79	1.59	0.00
2	GT-1 x JLS-116	7.27	-0.07	0.39 *
3	GT-1 x JLS-206-10	6.25	2.24	0.32 *
4	GT-1 x JLS-110-12	6.16	1.60**	-0.08
5	GT-1 x JLS-9707-2	5.66	1.20	-0.02
6	GT-1 x JLT-408	5.70	0.16**	-0.08
7	GT-1 x JLT-408-2	5.13	0.49	0.01
8	GT-1 x AKT-64	6.01	0.89	-0.08
9	GT-1 x PKV-NT-11	6.18	0.96	0.79 **
10	GT-1 x AKT-101	7.09	2.14**	-0.07
11	GT-2 x JLT-7	5.87	1.29	0.09
12	GT-2 x JLS-116	7.67	0.92	0.37 *
13	GT-2 x JLS-206-10	6.48	1.70**	-0.04
14	GT-2 x JLS-110-12	7.39	2.32*	0.12
15	GT-2 x JLS-9707-2	5.79	0.49	-0.01
16	GT-2 x JLT-408	6.04	1.59	0.47 *
17	GT-2 x JLT-408-2	4.41	0.34*	-0.02
18	GT-2 x AKT-64	5.74	0.70	0.00
19	GT-2 x PKV-NT-11	5.37	0.13	1.21 **
20	GT-2 x AKT-101	4.73	0.61**	-0.07
21	GT-3 x JLT-7	8.10	1.74	0.79 **
22	GT-3 x JLS-116	8.31	1.52	0.45 *
23	GT-3 x JLS-206-10	8.59	-1.04	1.07 **
24	GT-3 x JLS-110-12	7.79	-0.42**	-0.08
25	GT-3 x JLS-9707-2	9.05	1.74**	-0.07
26	GT-3 x JLT-408	8.76	1.50	0.46 *
27	GT-3 x JLT-408-2	6.24	2.66*	0.34 *
28	GT-3 x AKT-64	10.09	2.61**	-0.06
29	GT-3 x PKV-NT-11	9.76	-0.17	0.51 **
30	GT-3 x AKT-101	9.32	0.97	-0.02
31	PT-1 x JLT-7	6.10	0.62	-0.01
32	PT-1 x JLS-116	8.38	0.18	0.35 *
33	PT-1 x JLS-206-10	6.63	1.05	1.47 **
34	PT-1 x JLS-110-12	6.42	1.58	1.22 **
35	PT-1 x JLS-9707-2	7.12	-0.08	1.58 **
36	PT-1 x JLT-408	5.88	0.10**	-0.08
37	PT-1 x JLT-408-2	3.91	0.08*	0.06
38	PT-1 x AKT-64	4.00	0.30	0.58 **

Table 2. contd………..

Sr. No.	Genotypes	Mean	b_i	S^2di
39	PT-1 x PKV-NT-11	6.02	1.24	0.12
40	PT-1 x AKT-101	5.90	1.99	0.98 **
41	Patan-64 x JLT-7	6.14	1.58	0.06
42	Patan-64 x JLS-116	6.06	1.27	0.21
43	Patan-64 x JLS-206-10	5.45	1.56**	-0.07
44	Patan-64 x JLS-110-12	6.86	1.18	0.15
45	Patan-64 x JLS-9707-2	7.37	2.49*	0.18
46	Patan-64 x JLT-408	6.32	3.55	2.04 **
47	Patan-64 x JLT-408-2	4.67	0.32**	-0.04
48	Patan-64 x AKT-64	6.05	1.19	0.06
49	Patan-64 x PKV-NT-11	6.01	0.56	0.00
50	Patan-64 x AKT-101	7.82	1.73	1.81 **
	Mean (Crosses)	**6.62**		
51	G.Til-1	4.01	0.67	-0.06
52	G.Til-2	4.34	-0.03	0.16
53	G.Til-3	4.89	1.32	1.01 **
54	Phule Til No.1	5.25	0.14	0.29 **
55	Patan-64	5.17	0.54	2.07 **
56	JLT-7	5.51	0.74	0.11
57	JLS-116	4.88	0.30	0.14
58	JLS-206-10	5.41	0.23	0.51 **
59	JLS-110-12	5.91	1.33	0.15
60	JLS-9707-2	5.85	0.68	0.04
61	JLT-408	4.47	0.11	0.51 **
62	JLT-408-2	5.42	0.88	-0.04
63	AKT-64	5.80	0.81	0.02
64	PKV-NT-11	4.98	2.18	0.47 *
65	AKT-101	4.93	0.42	-0.01
66	G.Til-4 (c)	5.63	0.70	-0.01
67	TKG-22 (c)	5.14	1.14**	-0.08
	Mean (Parents)	**5.15**		

*, ** : Significant at 5% and 1% levels of significance respectively.

Table 3 . Classification of genotypes according to stability parameters for seed yield per plant.

Name of group	Criteria	Name/ No. of Genotypes: Crosses	Name/ No. of Genotypes: Parents	Suitability for cultivation
Average stable	High mean, b_i=1 but non significant and S^2d_i Non significant	G.Til-1 x JLT-7, G.Til-3 x AKT-101 and Patan-64 x JLS-110-12	JLT-7, JLS-110-12, JLS-9707-2, JLT-408-2, AKT-64 and G.Til-4	Suitable for general cultivation
Above average response	High mean, b_i >1 & significant and S^2d_i Non significant	G.Til-1 x AKT-101, G.Til -2 x JLS-110-12, G.Til -3 x JLS-9707-2, G.Til -3 x AKT-64 and Patan-64 x JLS-9707-2	Nil	Suitable for favorable environment
Below average response	High mean, b_i<1 & significant and S^2d_i Non significant	G.Til-3 x JLS-110-12	Phule Til No.1	Suitable for poor/ unfavorable environment
Unstable	High or Low mean, b_i=1, >1 or <1 and S^2d_i significant	20 crosses	6 parents	Unpredictable response in all environments

Table 4 . Classification of genotypes according to stability parameters for component traits.

Character		Groups			
		Average stable	Above average response	Below average response	Unstable
Capsules per plant	Crosses	10	3	0	18
	Parents	5	0	1	7
Capsule length	Crosses	15	3	1	6
	Parents	5	1	2	0
Seeds per capsule	Crosses	12	4	2	10
	Parents	4	1	2	6
1000-seed weight	Crosses	7	3	3	23
	Parents	5	1	1	7