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Stability analysis for seed yield and its contributing traits in sesame (*Sesamum indicum* L.)

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Abstract
Seventeen sesame (*Sesamum indicum* L.) genotypes including checks were evaluated in Randomized Block Design with two replications at Experimental Farm, department of genetics and plant breeding, college of agriculture, Latur during three environments *viz*. 2 July 2023, 17 July 2023 and 02 august 2023 and observations were recorded on the ten yield contributing characters *viz*. days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, length of capsule, number of seeds per capsule, 1000 seed weight (g), oil content (%) and seed yield per plant (g). In pooled analysis of variance for stability the genotypes, environments, environment (linear) and pooled deviations showed significant differences for most of the yield contributing characters evaluated, have shown divergent environments and the importance of non-linear component in the genotype x environment interaction. The genotypes TBS-05, V-32 were found stable for average environmental condition, TBS-09 and R-09 were found stable for favourable or better environmental condition and TBS-09, AKT-101(c) and TLT-10(c) were found stable for poor or unfavourable environmental conditions.

Keywords: Sesame, genotype environment interaction, variance, deviation, stable, regression coefficient

Introduction
The Sesame (*Sesamum indicum* L.) commonly known as til, is an ancient oilseed crop with a history of domestication spanning over 3000 years. Archaeological evidence of it can be found in Pakistan (2250 and 1750 BC) at Harappa in the Indus valley. Its oil is rich in antioxidants like sesamol and sesamolin, contributing to its long shelf life and uses in various industries including food, cosmetics, and pharmaceuticals. India's sesame cultivation spans 1620 thousand hectares with a production of 760 thousand tons and a productivity of 474 kg/ha. Maharashtra contributes 7000 ha, with a production of 2000 tons and a productivity of 279.8 kg/ha. The current experiment was carried out to evaluate seventeen sesame genotypes in terms of stability parameters for which they are subjected to three environments in *kharif* 2023. By implementing Eberhart and Russell's Model (1966) [11] Methods such as co-variance, stability variance, coefficient of determination, regression approach etc. with suitable parameters are available to provide necessary criteria to rank varieties for stability.

Materials and Methods
The seventeen genotypes of sesame including checks were evaluated in Randomized Block Design (R.B.D.) with two replications under three different sowing dates in *kharif* seasons at Experimental Farm, department of genetics and plant breeding, college of agriculture, Latur during different environments *viz*., E_1 (02 July 2023), E_2 (17 July 2023) and E_3 (02 august 2023). The line sowing was carried out at the spacing of 45 cm and 15 cm between the rows and plants respectively. The gross plot size was 0.90×4.00 m², while net plot size was 0.90 × 3.70 m². All other cultural package practices were undertaken to maintain healthy crop. The observations were recorded on ten characters *viz*. days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, length of capsule (cm), number of seeds per capsule, 1000 seed weight (g), oil content (%) and seed yield per plant (g). The collected data was subjected for testing the genotypic differences (Panse and Sukhatme (1967) [12]. Stability analysis was performed as per Eberhart and Russell (1966) [11] by considering three

stability parameters to describe the performance of genotypes over different environments.

Results and Discussion

Analysis of variance for Genotype × Environment interactions over three environments in sesame (Table No. 1) revealed that the variances due to genotypes were highly significant for all characters studied. The variances due to environment were highly significant for all the characters except number of capsules per plant, where as for genotype × environment interaction variances were significant for all characters except 1000 seed weight (gm). The variances due to environment + (genotype × environment) were highly significant for all characters, while the environment (linear) was significant for all characters except number of capsules per plant, indicating that a major part of variation could be attributed to linear regression. The significance of G × E interaction (linear) for all characters except 1000-seed weight suggesting that, the genotypes differed greatly in their linear response to different environments. Mean squares due to pooled deviation were found significant for days to 50% flowering, plant height (cm), number of branches per plant, number of capsules per plant and 1000 seeds weight (gm) and non-significant for days to maturity, capsule length (cm) number of seeds per capsule and oil content (%) Similar results were found earlier by Kumarsan and Nadarajan (2005) [2], Suvarna *et al*. (2011) [3], Patil *et al.* (2012) [4], Kumar *et al.* (2013) [5], Chaudhari *et al.* (2015) [6] and Mali *et al.* (2015) [7]

The assessment of per se performance (Table No. 2) revealed that the majority of genotypes in individual and pooled environment have shown encouraging per se performance of genotypes for almost all characters. The genotypes (41.33 days), AKT-101 (41.45 days) and TKG-22 (41.75 days) showed earliest flowering and TBS-05 (91.61 days) and R-09 (91.98 days) showed earliest maturity. The highest plant height recorded by AKT-101 (112.38 cm), TBS-02 (109.21 cm), TLT-10 (108.70 cm) and V-13 (105.88 cm). The genotypes TLT-05 (2.93), R-09 (2.75), AKT-101 (2.70), V-34 (2.61) and TBS-07 (2.55) showed a greater number of branches per plant and genotypes AKT-101 (54.40), TBS-06 (52.60) and V-13 (49.51) capsules per plant. The highest capsule length by TLT-10 (3.04 cm) and AKT-101 (3.00 cm), number of seeds per capsule by TKG-22 (72.36), AKT-101 (72.13), TLT-10 (71.60) and R-22 (71.18), 1000 seed weight for TBS-07 (3.92 g), TBS-05 (3.88 g), TBS-06 (3.86 g) and V-22 (3.75 g) was recorded. Highest oil content recorded by V-34 (53.70 %), TBS-09 (51.44 %) and V-21 (51.14 %) and highest seed yield per plant by TBS-05 (11.85 g), AKT-101(11.28 g) and TLT-10 (10.28 g).

Eberhart and Russell (1966) [11] model was used for stability analysis. The stability was assessed by considering the mean performance of the genotype over the environments (Xi), the linear regression of the genotypes over environment indices (bi) and the deviation from their regression (S^2di). The stable genotype is that one which have high mean, regression coefficient (bi) equal to unity and deviation from regression (S^2di) as non-significant. The Genotypes which recorded (bi) more than unity and non-significant deviation from regression shows below average stability which means genotypes are adaptable for better environment and the genotypes which recorded (bi) less than unity and non-significant deviation from regression shows above average stability means adaptable to poor environment.

Estimates of stability parameters for ten characters over three environments in sesame (Table No. 3) revealed that the genotypes TBS-05, V-32 for days to 50% flowering; TBS-02 and TBS-06 for days to maturity; V-21, R-09 and V-22 for plant height; TBS-02, TBS-07 and V-13 for number of branches per plant; TKG-22, V-32 and AKT-101 for number of capsules per plant; TBS-09, TBS-07, V-21 and R-22 for capsule length; TBS-09, R-22 and R-09 for number of seeds per capsule; TBS-05, TBS-06, TBS-07 and TLT-05 for 1000-seed weight; V-13, R-09 and TS-13 for oil content and TBS-05 and V-32 for seed yield per plant were found average stable in all environments.

The genotypes TBS-02 for days to 50% flowering; TBS-05, V-21, V-34, V-32 and TLT-10 for days to maturity; TBS-02, TBS-09, R-22, V-13 and TLT-05 for plant height; TBS-05, TBS-06, V-34, R-09 and V-32 for number of branches per plant; TBS-05 and TLT-10 for number of capsules per plant; TBS-05, V-13, TLT-05 and V-22 for capsule length; TKG-22 and TBS-05 for number of seeds per capsule; V-21 and V-34 for 1000- seed weight; TBS-09, TBS-05, R-22 and AKT-101 for oil content and TBS-09, R-09, V-22 and TLT-10 for seed yield per plant revealed below average stability and specifically adopted to favourable environments.

The genotypes TBS-07, R-22, TS-13 and TLT-10 for days to 50% flowering; TLT-05, TBS-09, R-09 and AKT-101 for days to maturity; TKG-22, AKT-101 and TLT-10 for plant height; R-22, TLT-05 and TLT-10 for number of branches per plant; TBS-02, TBS-07 and V-21 for number of capsules per plant; TS-13, AKT-101 and TLT-10 for capsule length; TBS-06, V-13 and TLT-10 for number of seeds per capsule; TBS-09, TKG-22 and V-32 for 1000-seed weight and V-34 for seed yield per plant showed above average stability and specifically adopted to poor environments. The studies on estimate of stability parameters revealed that none of the genotype was stable for all characters. Similar finding was recorded by Anuradha and Reddy (2008) [15], Suvarna *et al.* (2011) [3], Mirza *et al.* (2013), Mali *et al.* (2015) [7], Patil *et al.* (2015) [8], Raikwar *et al.* (2016) [9], Parveen *et al.* (2017) [15], Beniwal *et al.* (2018) [10], El rhman *et al.* (2022) [13], Rathod *et al.* (2023) [14].

Table 1: Analysis of variance for Genotype × Environment interactions over three environments in sesame

Source of variation	DF	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Capsule length (cm)	No. of seeds/ capsule	1000 seeds weight (gm)	Oil content (%)	Seed yield/ plant (gm)
Mean sum of squares											
Genotype	16	3.02**	7.35**	114.88**	0.33**	91.53**	0.11**	29.44**	0.175**	27.49**	4.61**
Environment+ (Genotype × Environment)	34	1.49**	0.65**	133.28**	0.94**	401.96**	0.04**	30.72**	0.07*	4.66**	11.57**
Environment	2	0.65**	1.07**	1692.25**	13.26**	5002.6	0.52**	171.22**	0.39**	0.58**	142.16**
Genotype × Environment	32	1.54**	0.62**	35.85**	0.18**	114.42**	0.01**	21.94**	0.05	4.91*	3.41**
Environment (linear)	1	1.30**	2.14**	3384.51**	26.52**	15.21	1.04**	342.44**	0.780**	1.17**	284.33**
Genotype × Environment (linear)	16	1.54**	0.75**	26.87**	0.19**	163.69**	0.02**	24.45**	0.04	2.86**	4.75**
Pooled deviation	17	1.45*	0.46	22.19**	0.15**	21.32**	0.006	18.285	0.06**	0.05	0.04

Pooled error	48	0.72	0.11	2.91	0.03	2.73	0.002	2.54	0.01	0.40	0.33
S.E. Mean		1.07	1.11	2.9	0.23	3.35	0.009	0.03	0.23	0.21	0.11
S.E. (bi)		0.31	0.26	0.4	0.36	5.64	0.13	0.01	0.65	0.41	0.07

Table 2: Mean performance of genotypes for seed yield and yield contributing characters over three environments in sesame

Sr. No.	Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches/ Plant	Number of capsules/ plant	Capsule length (cm)	Number of seeds/ capsule	1000 Seed Weight (g)	Oil content (%)	Seed yield/ plant (g)
1	TBS-02	45.63	96.33	109.21	2.30	46.83	2.50	67.10	3.26	47.06	7.18
2	TBS-09	41.90	9471	95.48	2.33	49.30	2.50	71.05	3.26	51.44	8.88
3	TKG-22	41.75	93.13	89.66	1.88	43.36	2..48	72.36	3.13	48.60	8.95
4	TBS-05	42.68	91.61	101.20	2.41	48.01	2.54	65.06	3.88	44.88	11.85
5	TBS-06	43.60	97.55	102.68	2.50	52.60	2.63	64.35	3.86	43.83	9.66
6	TBS-07	42.00	93.76	97.56	2.55	41.76	2.76	65.35	3.92	49.70	8.58
7	V-21	42.10	92.93	95.93	2.00	38.46	2.54	70.20	3.39	51.03	8.21
8	V-34	42.61	93.55	91.28	2.61	45.78	2.54	68.55	3.46	53.70	7.26
9	R-22	42.80	93.30	98.66	1.87	36.48	2.78	71.18	3.31	50.59	7.88
10	V-13	42.80	92.33	105.88	2.30	49.51	2.59	62.23	3.46	49.23	9.16
11	TLT-05	43.01	92.43	98.40	2.93	47.33	2.70	67.53	3.57	43.10	8.98
12	R-09	41.33	91.98	104.66	2.75	46.76	2.87	70.76	3.39	50.52	8.73
13	V-32	41.76	92.15	99.18	1.83	36.05	2.39	65.90	3.36	50.02	9.41
14	V-22	42.80	92.90	103.20	1.96	44.36	2.53	65.91	3.75	49.33	9.43
15	TS-13	42.90	93.03	103.38	2.41	36.60	2.87	70.36	3.49	50.64	9.90
16	AKT-101	41.45	93.63	112.38	2.70	54.40	3.00	72.13	3.32	49.20	11.28
17	TLT-10	42.23	92.00	108.70	2.53	46.46	3.04	71.60	3.72	43.99	10.28
	Mean	42.55	93.37	101.02	2.34	44.94	2.66	68.33	3.50	48.64	9.15

Sr. No.	Genotype	Days to 50% flowering			Days to maturity			Plant height (cm)		
		Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di
1	TBS-02	45.63	2.34	0.13	96.33	1.08	0.08	109.21	1.45	0.05
2	TBS-09	41.90	1.21	0.41	94.71	-0.49	0.08	95.50	1.35	0.08
3	TKG-22	41.75	4.99	0.66	93.13	0.09	-0.89	102.70	0.36	0.88
4	TBS-05	42.68	1.02	0.20	91.61	2.03	-0.29	101.20	1.27	29.02*
5	TBS-06	43.60	1.12	0.05	97.55	1.05	0.07	102.70	0.96	1.82
6	TBS-07	42.00	-3.16	-0.15	93.76	-0.14	0.06	97.60	0.82	2.10
7	V-21	42.10	5.83	1.53	92.93	2.32	-0.67	101.90	1.01	0.08
8	V-34	42.61	4.73	4.04*	93.55	1.26	-0.56	91.30	0.48	-3.00
9	R-22	42.80	-2.02	-0.68	93.30	0.33	-0.86	98.70	1.43	0.60
10	V-13	42.80	-0.29	-0.31	92.33	1.61	-0.42	105.90	1.43	0.32
11	TLT-05	43.01	1.03	0.07	92.43	-0.26	-0.02	98.40	1.47	0.29
12	R-09	41.33	6.10	0.16	91.98	-0.67	0.06	104.70	1.05	0.05
13	V-32	41.76	1.15	0.02	92.15	2.53	0.05	99.20	0.84	65.01**
14	V-22	42.80	6.53	-0.03	92.90	0.14	-0.86	103.20	1.05	0.07
15	TS-13	42.90	-3.40	-0.61	93.03	0.04	-0.91	103.30	0.85	-2.54
16	AKT-101	41.45	-5.17	2.22*	93.63	-0.90	0.38	112.40	0.61	0.04
17	TLT-10	42.23	-8.81	0.08	92.00	2.11	-0.70	108.70	0.49	0.03
	Mean	42.55			93.37			101.02		

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

Sr. No.	Genotype	Number of branches/plant			Number of capsules/plant			Capsule length (cm)		
		Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di
1	TBS-02	2.41	1.06	0.01	46.83	0.32	-0.01	2.50	0.84	0.01
2	TBS-09	2.33	0.82	0.47**	49.30	2.09	76.93**	2.70	1.06	0.01
3	TKG-22	1.88	0.37	0.41**	43.36	1.05	0.06	2.48	0.82	0.01
4	TBS-05	2.41	1.27	0.08	48.01	1.24	0.03	2.54	1.88	0.01
5	TBS-06	2.50	1.52	-0.04	52.60	0.48	109.40**	2.63	1.62	0.01
6	TBS-07	2.55	1.03	-0.01	41.76	0.76	-0.67	2.76	1.05	0.01
7	V-21	2.00	1.14	-0.02	38.46	0.75	-0.64	2.54	1.03	0.01
8	V-34	2.61	1.55	0.01	45.78	1.28	105.06**	2.54	-0.03	0.01
9	R-22	1.87	0.63	-0.04	36.48	0.51	88.46**	2.78	1.04	0.01
10	V-13	2.35	1.01	-0.01	43.51	0.98	0.15	2.59	1.89	0.01
11	TLT-05	2.93	0.56	0.11	47.33	0.74	11.51*	2.70	2.00	0.01
12	R-09	2.75	1.24	0.07	46.76	0.88	77.34**	2.87	0.48	0.01
13	V-32	1.83	1.45	0.05	36.05	1.05	0.09	2.39	0.98	0.01
14	V-22	1.96	0.73	0.24*	44.36	0.87	131.64**	2.53	2.12	0.01
15	TS-13	2.41	1.15	0.51**	36.60	0.49	0.06	2.87	0.58	0.01

16	AKT-101	2.70	0.91	-0.04	42.40	1.09	0.01	3.00	0.62	-0.01
17	TLT-10	2.53	0.53	0.02	46.46	1.93	0.03	3.04	0.46	0.01
	Mean	2.34			44.94			2.66		

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

Table 3: Estimates of stability parameters for ten characters over three environments in sesame

Sr. No.	Genotype	Number of seeds/capsule			1000 Seed weight (g)		
		Xi	bi	S²di	Xi	bi	S²di
1	TBS-02	67.10	0.77	8.12	3.26	1.04	0.01
2	TBS-09	71.05	1.02	0.07	3.57	0.49	0.04
3	TKG-22	72.36	2.02	0.02	3.61	0.19	0.03
4	TBS-05	65.06	2.08	0.09	3.88	1.06	0.02
5	TBS-06	64.35	0.29	0.01	3.86	1.09	0.05
6	TBS-07	65.35	-1.55*	42.35**	3.92	1.05	0.01
7	V-21	70.20	1.30	0.38	3.61	2.56	0.07
8	V-34	68.55	1.44	5.19	3.58	2.38	0.06
9	R-22	71.18	1.03	0.08	3.31	-0.92	0.13*
10	V-13	62.23	0.48	0.09	3.46	1.46	0.18**
11	TLT-05	67.53	1.12	0.32	3.57	1.01	0.07
12	R-09	70.76	1.07	0.05	3.39	1.75	0.15**
13	V-32	65.90	1.41*	19.70*	3.58	0.35	0.01
14	V-22	65.91	-0.06*	3.22	3.75	-0.28	0.10*
15	TS-13	70.36	1.89	40.87**	3.49	1.75	0.13**
16	AKT-101	67.13	0.98	0.13	3.32	1.72	0.11**
17	TLT-10	71.60	0.80	0.09	3.72	0.14	0.15**
	Mean	68.33			3.50		

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

Sr. No.	Genotype	Oil content (%)			Seed yield/plant (gm)		
		Xi	bi	S²di	Xi	bi	S²di
1	TBS-02	47.06	0.12	0.06	7.18	0.19	-0.03
2	TBS-09	51.44	2.99	0.04	8.88	1.68	0.03
3	TKG-22	48.60	-0.02	-0.44	8.95	1.03	0.04
4	TBS-05	48.88	4.28	0.08	11.85	1.08	0.07
5	TBS-06	43.83	-6.86	-0.33	9.66	0.58	2.47**
6	TBS-07	49.70	-0.54	-0.44	8.58	0.69	1.15*
7	V-21	44.03	0.05	-0.33	8.21	0.69	1.02**
8	V-34	53.70	-2.22	-0.39	7.26	0.84	0.09
9	R-22	50.59	7.83	0.08	7.88	0.59	1.84*
10	V-13	49.23	1.09	0.06	9.16	0.77	-0.12
11	TLT-05	43.10	0.25	-0.28	8.98	0.97	0.80
12	R-09	50.52	1.12	0.09	8.73	1.62	0.03
13	V-32	42.02	0.13	0.14	9.41	1.06	0.05
14	V-22	49.33	-0.01	-0.05	9.43	1.41	0.05
15	TS-13	50.64	1.09	0.09	9.05	1.18	0.33
16	AKT-101	49.20	1.60	-0.40	11.28	1.17	3.12**
17	TLT-10	43.99	-8.71	0.37	10.28	1.56	0.01
	Mean	48.64			9.15		

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

Conclusion

The conducted experiment revealed that none of the genotype was found stable for all characters under studied. On the basis of mean performance, the genotypes TBS-05, AKT-101 and TLT-10 found for high seed yield. The genotypes TBS-05, V-32 were found stable for average environmental condition, TBS-09 and R-09 were found stable for favourable or better environmental condition and TBS-09, AKT-101(c) and TLT-10(c) were found stable for poor or unfavourable environmental conditions.

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