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

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Abstract
Twenty sesame (*Sesamum indicum* L.) genotypes including checks were evaluated in Randomized Block Design with two replication at Oilseeds Research Station, Latur during three environments viz. summer (2021), kharif (2021) and rabi (2021-22). The data were recorded on the 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 characters studied, indicating divergent environments and the importance of non-linear component in the genotype-environment interaction. The genotypes TBS-09 and TS-14 were found stable for average environmental condition, TBS-07, TS-11 and TS-14 were found stable for favourable environmental condition and TBS-10, TBS-12 and JLT-408(c) were found stable for poor environmental condition.

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

Introduction
Sesame (*Sesamum indicum* L.) (2n=26) is known by several names, including sesamum, gingelly, til, tila, simsim, and gergelim. Sesame is one of the oldest cultivated oilseed crops on the planet. The majority of sesame wild relatives are found in Sub-Saharan Africa (Bedigian, 2003) [7], however a few are found in India (Desai, 2004) [5]. Archeological evidence of it can be found in Pakistan (2250 and 1750 BC) at Harappa in the Indus valley. The experiment was conducted with an objectives to study the stability of sesame entries in different environment and to study the correlation and path analysis for yield and yield contributing characters. Methods such as co-variance, stability variance, coefficient of determination, regression approach (Eberhart and Russell, 1966) [6] etc. with suitable parameters are available to provide necessary criteria to rank varieties for stability. Eberhart and Russell's Model (1966) [6] is the most popular.

Materials and Methods
The experimental material comprised of twenty sesame genotypes including checks were evaluated in Randomized Block Design (R.B.D.) with two replications under three different seasons at Oilseeds Research Station Latur during different environments *viz.*, E1 (Summer 2021), E2 (*Kharif* 2021) and E3 (*Rabi* 2021-22).The sowing was carried out at the spacing of 45 cm and 10 cm between the rows and plants respectively. The method of sowing followed was dibbling. One plant per hill was maintained by thinning 15 days after sowing. The gross plot size was 1.80 x 4.0 m², while net plot size was 1.80 x 3.60 m². The recommended dose of fertilizer 30 kg N + 60 kg P_2O_5 + 30 kg K_2O per hectare was applied at time of sowing. All other cultural 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) [10]. Stability analysis was performed as per Eberhart and Russell (1966) [6] by considering three stability parameters to describe the performance of genotypes over different environments.

Results and Discussion

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 (Table 1). 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). Supporting results were found by Chaudhari *et al.* (2015) [4], Kumarsan and Nadarajan (2005) [8], Patil (2012) [11], Mali *et al.* (2015) [9], Suvarna *et al.* (2011) [14] and Kumar *et al.* (2013) [7].

The stability in the performance of a variety is as important as its mean yield stated by Johnson *et al.* (1968) [15]. The assessment of *per se* performance revealed that the majority of genotypes in individual and pooled environment have shown encouraging *per se* performance of genotypes for almost all characters (Table 2). The genotypes V-21 and TKG-22(c) (41.00 days) showed earliest flowering and R-33 (88.33 days) showed earliest maturity. The highest plant height recorded by TBS-09 (119.90 cm) and TBS-10 (116.53 cm). The genotypes TBS-02 (4.16) and TBS-06 (4.13) showed more number of branches per plant and the genotypes TBS-05 (78.21) and TBS-02 (76.13) showed highest number of capsules per plant. The highest capsule length recorded by Sweta(c) (3.01 cm), number of seeds per capsule by TBS-12 (71.95), 1000 seed weight by TBS-12 (4.65 g). Highest oil content recorded by check Sweta (47.15%) and highest seed yield per plant by TBS-09 (15.82 g) and TBS-05 (14.73 g).

The stability parameters regarding yield and yield contributing traits are given in Table 3. Eberhart and Russell (1966) [6] 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 and the genotypes which recorded bi less than unity and non significant deviation from regression shows above average stability.

The genotypes R-33, V-09 and V-21 for days to 50% flowering; TS-11 and TBS-02 for days to maturity; TBS-09 and V-34 for number of branches per plant; TBS-06, TS-14, TBS-12 and TBS-09 for capsule length; Sweta(c), TBS-12 and TS-13 for number of seeds per capsule; TBS-02, TBS-06, TBS-10 and TS-14 for 1000-seed weight; V-21, R-33 and V-34 for oil content and TBS-09 and TS-14 for seed yield per plant were found average stable in all environments.

The genotypes TKG-22(c) for days to 50% flowering; TBS-09, TBS-07, R-33, R-09 and TKG-22(c) for days to maturity; TBS-06, TBS-07 and R-09 for plant height; TBS-10, TS-14 and JLT-408(c) for number of branches per plant; TBS-07 and TS-14 for number of capsules per plant; TBS-02, V-18, TS-11 and Sweta(c) for capsule length; R-33 and TS-14 for number of seeds per capsule; TBS-05 and TS-11 for 1000-seed weight; Sweta, JLT-408, TS-11 and TS-13 for oil content and TBS-02, TBS-05, TBS-06 and TBS-07 for seed yield per plant revealed below average stability and specifically adopted to favourable environments.

The genotypes TBS-10, TBS-12, V-32, JLT-408 and TBS-02 for days to 50% flowering; V-21, TBS-10, JLT-408 and TBS-12 for days to maturity; TS-13, TS-14 and V-34 for plant height; TS-11 and V-18 for number of branches per plant; TBS-06, TS-11 and JLT-408 for number of capsules per plant; TBS-10, R-09 and TS-13 for capsule length; TBS-09, V-34 and TS-11 for number of seeds per capsule; TBS-07, TBS-09, TBS-12 for 1000-seed weight and TBS-10 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) [1], Mali *et al*. (2015) [9], Patil *et al*. (2015) [12], Raikwar (2016) [13], Beniwal *et al*. (2018) [3].

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 (g)	Oil content (%)	Seed yield/ plant (g)
Mean sum of squares											
Genotype	19	15.79**	20.17**	491.88**	1.55**	583.19**	0.10**	67.50**	0.44**	13.94**	24.97**
Environment+ (Genotype × Environment)	40	18.00**	26.35**	119.95**	0.70**	64.83**	0.01**	25.96**	0.26*	0.45**	5.04**
Environment	2	236.44**	362.38**	1006.13**	8.10**	7.08	0.09**	183.41**	2.53**	5.25**	44.00**
Genotype × Environment	38	6.51**	8.67**	73.31**	0.31**	67.87**	0.01**	17.67**	0.14	0.20*	2.99**
Environment (linear)	1	472.89**	724.76**	2012.27**	16.21**	14.16	0.18**	366.83**	5.07**	10.51**	88.00**
Genotype × Environment (linear)	19	10.58**	14.73**	129.02**	0.50**	112.02**	0.02**	35.35**	0.16	0.31**	5.96**
Pooled deviation	20	2.31*	2.47	16.73**	0.11**	22.53**	0.0001	-0.002	0.10**	0.08	0.02
Pooled error	57	1.07	1.83	3.54	0.01	1.66	0.01	1.89	0.01	0.33	0.77
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

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

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	43.50	90.83	109.50	4.16	76.13	2.82	61.57	4.12	40.93	14.02
2	TBS-05	44.00	95.16	115.73	3.98	78.21	2.58	62.38	4.05	39.11	14.73
3	TBS-06	45.66	95.50	109.58	4.13	62.96	2.89	60.25	4.25	39.42	12.26
4	TBS-07	45.16	91.73	108.81	3.95	54.78	2.70	61.61	4.28	40.64	11.77
5	TBS-09	44.33	92.36	119.90	3.43	71.05	2.89	70.15	3.97	40.78	15.82
6	TBS-10	42.50	90.16	116.53	3.60	57.03	2.81	60.40	4.12	39.05	10.19
7	TBS-12	43.16	92.50	111.78	3.23	53.35	2.96	71.95	4.65	41.65	9.40
8	R-09	42.33	91.66	104.33	3.05	49.08	2.77	62.57	3.44	41.13	7.71
9	R-22	47.83	100.33	96.35	2.40	35.98	2.59	62.63	3.75	41.06	6.66
10	R-33	41.33	88.33	76.45	1.61	24.78	2.35	64.44	3.13	43.94	5.67
11	V-18	50.16	93.63	93.18	3.26	38.80	2.78	58.62	3.61	40.16	7.21
12	V-21	41.00	90.53	95.63	3.23	39.31	2.65	58.07	3.16	43.09	7.55
13	V-32	42.16	94.42	96.68	1.58	39.66	2.33	55.64	3.61	41.00	6.91
14	V-34	43.66	95.88	102.98	3.64	49.40	2.68	64.35	3.88	45.08	8.69
15	TS-11	45.50	92.60	114.40	3.78	59.68	2.78	67.47	3.96	45.11	9.06
16	TS-13	44.33	93.50	113.95	3.01	50.31	2.94	70.59	4.05	42.22	9.38
17	TS-14	44.16	93.30	107.55	3.61	57.31	2.90	68.33	4.31	40.36	10.81
18	TKG-22(c)	41.00	92.33	75.66	2.90	45.16	2.65	59.71	4.07	41.49	7.36
19	JLT-408(c)	42.33	91.00	94.20	3.31	59.21	2.55	59.21	3.82	43.04	9.20
20	Sweta (c)	45.83	94.66	87.00	2.96	37.26	3.01	70.05	3.62	47.15	6.61
	Mean	44.00	93.02	102.5	3.24	51.97	2.73	63.50	3.89	41.82	9.55

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

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	43.50	0.41	0.94	90.83	0.87	-1.49	109.50	2.30	17.10*
2	TBS-05	44.00	0.50	-0.36	95.16	0.26	3.79	115.73	2.82	38.01**
3	TBS-06	45.66	2.09	4.63*	95.50	1.67	0.62	109.58	1.36	-2.56
4	TBS-07	45.16	1.17	-0.94	91.73	1.63	0.25	108.81	1.43	-1.98
5	TBS-09	44.33	1.93	3.10	92.36	1.79	1.77	119.90	2.09	10.78
6	TBS-10	42.50	0.18	2.66	90.16	0.63	-0.10	116.53	1.37	20.74*
7	TBS-12	43.16	0.26	2.03	92.50	0.36	1.05	111.78	-0.17	15.34*
8	R-09	42.33	1.25	-0.80	91.66	1.37	-1.39	104.33	1.61	-1.12
9	R-22	47.83	1.71	1.27	100.33	0.79	1.48	96.35	1.03	-3.80
10	R-33	41.33	1.02	-1.04	88.33	1.38	0.45	76.45	1.05	-3.97
11	V-18	50.16	1.86	2.43	93.63	2.48	12.98**	93.18	1.34	-2.75
12	V-21	41.00	0.64	-0.25	90.53	0.68	0.64	95.63	2.00	5.67
13	V-32	42.16	0.26	2.03	94.42	-0.42*	-1.88	96.68	2.60	28.38**
14	V-34	43.66	2.03	8.09**	95.88	1.26*	-1.91	102.98	0.42	2.80
15	TS-11	45.50	0.64	-0.25	92.60	1.10	-1.92	114.40	-0.78	39.25**
16	TS-13	44.33	0.56	0.09	93.50	0.68	0.59	113.95	0.25	4.25
17	TS-14	44.16	0.72	-0.53	93.30	0.79	-1.11	107.55	-0.08	9.42
18	TKG-22 (c)	41.00	1.78	1.82	92.33	1.29	-1.85	75.66	-0.79	35.16**
19	JLT-408 (c)	42.33	0.34	1.45	91.00	0.57	0.40	94.20	-0.96	48.46**
20	Sweta (c)	45.83	0.65	-0.81	94.66	0.81	-1.23	87.00	1.11	-3.95
	Mean	44.00			93.02			102.5		

* 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	4.16	2.05	0.17**	76.13	20.85	57.26**	2.82	1.78	-0.01
2	TBS-05	3.98	2.34	0.25**	78.21	25.91	91.27**	2.58	2.52	-0.01
3	TBS-06	4.13	1.73	0.13**	62.96	-6.21	6.06	2.89	0.96	-0.01
4	TBS-07	3.95	2.14	0.24**	54.78	8.42	6.48	2.70	2.08*	-0.01
5	TBS-09	3.43	1.15	-0.01	71.05	-8.42	11.56**	2.89	1.56	-0.01
6	TBS-10	3.60	1.40	0.02	57.03	-14.85	35.96**	2.81	0.23	-0.01
7	TBS-12	3.23	1.48	0.06	53.35	-11.72	22.54**	2.96	0.45	-0.01
8	R-09	3.05	0.98	-0.01	49.08	2.86	-1.24	2.77	-1.33	-0.01
9	R-22	2.40	1.03	-0.01	35.98	-0.97	-1.17	2.59	-2.53*	-0.01
10	R-33	1.61	-0.12	0.18**	24.78	3.79	-0.60	2.35	3.71*	-0.01
11	V-18	3.26	0.74	-0.01	38.80	-0.97	-1.23	2.78	1.78	-0.01
12	V-21	3.23	0.94	0.16**	39.31	8.59	6.88	2.65	2.23*	-0.01

13	V-32	1.58	-0.69	0.35**	39.66	-24.59	96.51**	2.33	1.04	-0.01
14	V-34	3.64	1.17	-0.01	49.40	14.46	25.37**	2.68	-2.67*	-0.01
15	TS-11	3.78	0.13	0.07	59.68	-3.35	1.09	2.78	2.16	-0.01
16	TS-13	3.01	0.18	0.19**	50.31	-13.09	28.04**	2.94	0.30	-0.01
17	TS-14	3.61	1.34	0.02	57.31	8.46	6.58	2.90	0.89	-0.01
18	TKG-22 (c)	2.90	0.24	0.09*	45.16	-1.06	-1.12	2.65	-0.74*	-0.01
19	JLT-408 (c)	3.31	1.28	0.02	59.21	-2.51	0.10	2.55	3.71*	-0.01
20	Sweta (c)	2.96	0.48	0.02	37.26	14.41	25.19**	3.01	1.86	-0.01
	Mean	3.24			51.97			2.73		

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

Sr. No.	Genotype	Number of seeds/capsule			1000 Seed weight (g)		
		Xi	bi	S^2di	Xi	bi	S^2di
1	TBS-02	61.57	2.32*	-1.96	4.12	0.93	-0.01
2	TBS-05	62.38	1.33*	-1.96	4.05	1.50	0.04
3	TBS-06	60.25	0.12*	-1.95	4.25	1.05	-0.01
4	TBS-07	61.61	3.30*	-1.96	4.28	0.68	0.02
5	TBS-09	70.15	0.73	-1.96	3.97	0.63	0.00
6	TBS-10	60.40	0.08*	-1.95	4.12	1.26	-0.01
7	TBS-12	71.95	1.12	-1.96	4.65	0.74	-0.01
8	R-09	62.57	-1.96*	-1.95	3.44	-0.49	0.32**
9	R-22	62.63	0.67*	-1.96	3.75	1.76	0.04
10	R-33	64.44	2.72	-1.96	3.13	2.50	0.36**
11	V-18	58.62	0.34*	-1.95	3.61	1.22	-0.01
12	V-21	58.07	0.87	-1.96	3.16	1.45	0.05
13	V-32	55.64	0.78	-1.96	3.61	0.49	0.08**
14	V-34	64.35	-0.96	-1.95	3.88	1.94	0.15**
15	TS-11	67.47	0.62	-1.96	3.96	1.41	0.01
16	TS-13	70.59	0.78	-1.96	4.05	-0.11	0.21**
17	TS-14	68.33	1.89	-1.96	4.31	0.77	-0.01
18	TKG-22 (c)	59.71	0.04	-1.95	4.07	-0.35	0.37**
19	JLT-408 (c)	59.21	4.12*	-1.96	3.82	2.35	0.29**
20	Sweta (c)	70.05	1.09	-1.96	3.62	0.29	0.05
	Mean	63.50			3.89		

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

Sr. No.	Genotype	Oil content (%)			Seed yield/plant (g)		
		Xi	bi	S^2di	Xi	bi	S^2di
1	TBS-02	40.93	2.03	-0.20	14.02	3.57	-0.80
2	TBS-05	39.11	1.14	-0.36	14.73	3.89	0.80
3	TBS-06	39.42	0.48	-0.34	12.26	1.77	-0.82
4	TBS-07	40.64	0.05	-0.24	11.77	2.34	-0.80
5	TBS-09	40.78	0.62	-0.34	15.82	1.06	-0.81
6	TBS-10	39.05	1.03	-0.35	10.19	0.02	-0.81
7	TBS-12	41.65	0.53	-0.36	9.40	0.97	-0.81
8	R-09	41.13	0.35	-0.22	7.71	0.16*	-0.82
9	R-22	41.06	-0.80	0.11	6.66	-0.04*	-0.82
10	R-33	43.94	0.98	-0.35	5.67	-0.30*	-0.82
11	V-18	40.16	0.89	-0.36	7.21	0.51*	-0.82
12	V-21	43.09	1.01	-0.35	7.55	0.66*	-0.82
13	V-32	41.00	0.67	-0.31	6.91	-0.48*	-0.82
14	V-34	45.08	0.89	-0.36	8.69	0.72*	-0.82
15	TS-11	45.11	1.16	-0.35	9.06	1.71	-0.80
16	TS-13	42.22	1.29	-0.35	9.38	0.90	-0.82
17	TS-14	40.36	0.93	-0.36	10.81	0.86	-0.40
18	TKG-22 (c)	41.49	2.34	-0.01	7.36	0.17*	-0.81
19	JLT-408 (c)	43.04	2.15	-0.18	9.20	0.75	-0.80
20	Sweta (c)	47.15	2.26	-0.12	6.61	0.77*	-0.82
	Mean	41.82			9.55		

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

Conclusion

On the basis of mean performance and stability, the genotypes TBS-09 and TS-14 found for high seed yield and showed wider adaptability. The genotypes TBS-09 and TS-14 showed stable performance in average environmental condition. Below average stability showed by the genotypes TBS-07, TS-11 and TS-14 under favourable environmental condition. The genotypes TBS-10, TBS-12, TS-11 and JLT-408(c) recorded above average stability and specially to adapted to poor environments. It is revealed that none of the genotype

was found stable for all characters under studied.

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