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Study on stability of seed yield in sesame (*Sesamum indicum* L.)

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Abstract
An experiment was conducted using thirty advanced cultures and released varieties of sesame for understanding the stability of genotypes for seed yield over years. IPCA 1 has the major role in deciding the G x E interaction in this study. As the experiment was conducted in rabi seasons of three consecutive years, the mean seed yield was higher during first year and was lower in the third year. From AMMI analysis, it was found that the genotypes COS 15003, COS 15204, COS 15212, COS 15213 and COS VRI 2 had the IPCA 1 score close to zero and were less influenced by the environment. The entries COS 15020 and COS 15016Br were also identified as high yielding but had moderate influence of G x E interactions. In Ammi 2 Biplot analysis, the genotypes COS 15003, COS 15204, COS 15207, COS 15211 and VRI 2 were very close to the centre of the origin and are not sensitive to the environmental interactions. In GGE Biplot, E1 fell in the sector in which COS 15011was the vertex cultivar, for E2 sector COS 15010 and COS 15022 is at the vertex for environment 3. The genotypes COS 15003, COS 15204 and VRI 2 were less interacting genotypes over environments along with high seed yield. These genotypes may be recommended for cultivation during rabi seasons.

Keywords: Sesame, stability, AMMI, GGE biplot, seed yield

Introduction

Sesame, *Sesamum indicum* L. is an important oilseed crop of tropical and subtropical region. It is regarded as the 'Queen of Oilseeds' due to the quality of oil having high nutritional and therapeutic value. Sesame seeds contain around 50 per cent of oil which is rich in antioxidants and different fatty acids like oleic acid (43%), linoleic acid (35%), palmitic acid (11%) and stearic acid (7%). The crop is tolerant to drought conditions and suitable for well-drained soils. The crop can be grown in various agro-climatic conditions of India. Under high temperature, it can set seeds and can grow in stored soil moisture without rainfall and irrigation.

Sesame production was 6.0 m.t. globally during 2018 (FAOSTAT, 2018) [4]. India ranks first in the world in sesame cultivation with an area of about 27.7 per cent but its productivity is low to the tune of 368 kg / ha as compared to world's average of 489 kg / ha. Narrow genetic resources, growing in marginal lands under complete rainfed condition, lack of wide adaptability and non-synchronous maturity due to indeterminate growth are major problems in achieving higher seed yield in sesame. The variability in environment namely location effect, seasonal fluctuations and their interaction highly influence the adaptation and performance of genotypes in relation to yield potential. Sesame genotypes showed different performance under different sesame growing environments. Failure of genotypes to respond consistently to variable environmental conditions is attributed to Genotype and Environment interaction (Mohammed and Firew, 2015) [5]. Hence, identification of stable genotypes over wider environment is an important but a challenging task to breeders. The stability of a genotype over diverse environments is usually tested by the degree of its interaction with different environments under which it is grown (Asif *et al*. 2003) [1]. As sesame crop has high response to the changes in environmental factors, an attempt was made to identify the stable genotypes among the advanced cultures and released varieties.

Materials and Methods

There is always a need to test the newly developed cultivars across different environments and over seasons / years in order to elucidate the pattern and magnitude of genotype x environment interactions. So, identification of highly stable and adapted sesame cultivar with stable yield under various environments will be of immense use to the farming community. The experimental material consisted of thirty advanced cultures and ruling varieties in sesame.

The crop was raised in randomized block design with two replications in a plot size of $6m^2$ over years during Rabi 2017, Rabi 2018 and Rabi 2019 in different locations at Agricultural Research Station, Bhavanisagar. The data was recorded for four characters, *viz* days to 50% flowering, number of branches/ plant, number of capsules/plant and plot yield (g). For number of branches/ plant, number of capsules/plant, the observations were recorded in ten randomly selected plants in the middle rows of the plot in both the replications. The recommended package of practices was followed to raise a good crop.

Among different biometrical techniques used to assess the G x E interactions, as the models like Principle Component Analysis (PCA) and linear regression analysis are not adequate in treating the complex data of yield trials effectively (Zobel *et al.*, 1988) [10], AMMI model had both additive and multiplicative effects was applied for the identification of stable genotypes.

Results and Discussion

Many statistical methods are used for the analysis of genotypes by environment interactions (GEI) and phenotypic stability (Crossa *et al*., 1990) [2]. Earlier, regression techniques developed by Eberhart and Russell, (1966) [3]; Perkins and Jinks, (1968) [6] were widely used. Zobel *et al.* (1988) [10] reported that traditional analysis was not always effective in the interpretation of the multi-environment trial data. Among various factors influencing the economic yield, G x E interaction is very important. As the environmental factors are having huge impact on the growth of individual genotypes, it is imperative to study the response of the genotypes to different environments.

In the present study, the analysis of variance for stability revealed the presence of significant difference among the genotypes in different seasons and also due to the interaction of genotypes x environment for the traits studied (Table 1). Apart from the significance of IPCA 1 and IPCA 2, the IPCA 1 alone recorded 66.6 percent and IPCA 2 showed 33.4 percent of total sum of squares. Hence IPCA 1 has the major role in deciding the G x E interaction in this study.

Seed yield

Yield is an important trait observed for studying the stability of the genotypes over season or environment. The mean seed yield in this experiment ranged from 1098.4 kg/ m^2 in COS to 693.2 kg/ha in SVPR 1. As the experiment was conducted in rabi seasons of three consecutive years, the mean seed yield was higher (938.5 kg/ha) during first year and was lower (851.6 kg/ha) in the third year. The entries COS 15010, COS 15011 and COS 15001recorded the highest mean yield of 1098.4 kg/ha, 1086.5 kg/ha and 1083.2 kg/ha respectively (Table 2).

Among the thirty genotypes evaluated for seed yield over three years, the genotypes COS 15003, COS 15204, COS 15212, COS 15213 and COS VRI 2 had the IPCA 1 score close to zero indicating that these genotypes were less influenced by the environment (Fig. 1). Hence, the above said genotypes were stable and had general adaptability over locations and years. The check variety VRI 2 was identified as less influenced by the environment and stable in performance. The genotypes COS 15001, COS 15010 and 15011, though they were high yielding, they were highly influenced by the G x E interactions and are not stable. The entries COS 15020 and COS 15016Br were also identified as high yielding but had moderate influence of G x E interactions. Hence these genotypes can be recommended for further study. Among the environments, Environment 1 was identified as high yielding

In AMMI 2 biplot (Fig. 2), IPCA1 and IPCA 2 values were plotted. In this graph, environments with short spokes did not exert strong interactive forces. Those with long spokes exerted strong interaction. In this experiment, all the three environments had shown long spokes and hence expressed strong interaction with the genotypes used for this study. In case of genotypes *viz.*, COS 15003, COS 15204, COS 15207, COS 15211 and VRI 2 were very close to the centre of the origin, indicating that they are not sensitive to the environmental interactions. Hence, these genotypes can be classified as stable in performance. The genotypes COS 15023, COS 15206, COS 15208, COS 15214 and COS 15215 were susceptible to environmental interactions and hence would not be considered as stable genotypes.

The GGE biplot graph (Fig. 3), graphically addresses the crossover of GE, ME differentiation, specific adaptation etc. (Rao *et al.*, 2011; Rakshit *et al.*, 2012) [8, 7] and are constructed by joining the farthest genotypes to form a polygon. The genotypes at the vertices of the polygon are the best or worst genotypes in one or more environments and the genotype at the vertex of the polygon is the best performing genotype in the environments falling within the sector (Yan and Tinker, 2006) [9]. The equality lines divided the biplot for seed yield into six sectors effectively of which three retained all the three environments.

For seed yield, E1 fell in the sector in which COS 15011was the vertex cultivar, for E2 sector COS 15010 and COS 15022 is at the vertex for environment 3. This indicated COS 15011 was the best genotype for E1, similarly COS 15011 and COS 15022 were the best genotypes for E2 & E3 respectively for seed yield.

Based on this study, it was concluded that the genotypes COS 15003, COS 15204 and VRI 2 were less interacting genotypes over environments along with high seed yield. These genotypes may be recommended for cultivation during rabi seasons.

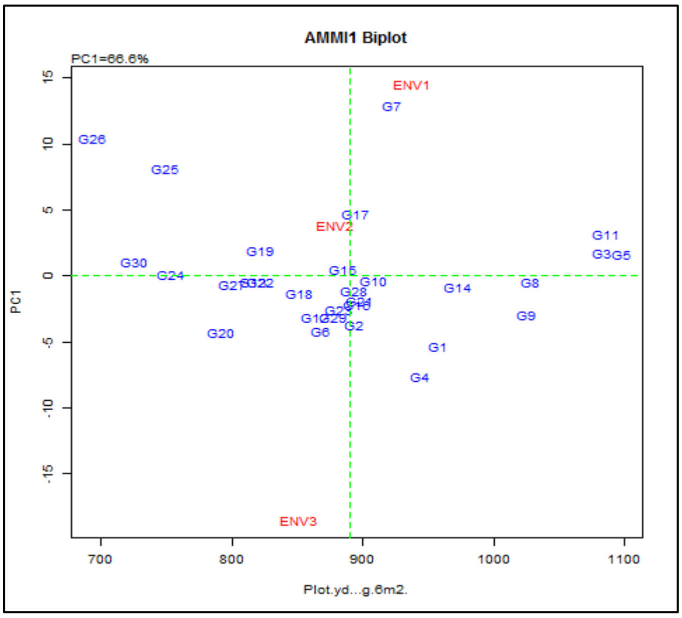

Fig 1: Scatter plot of Plot Yield with IPC 1 in AMMI analysis

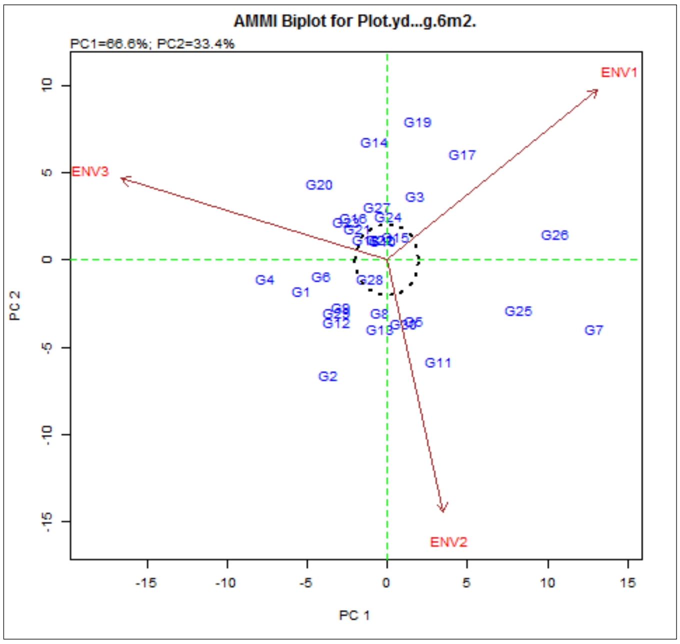

Fig 2: Scatter plot of IPC 1 vs IPC 2 for plot yield in AMMI analysis

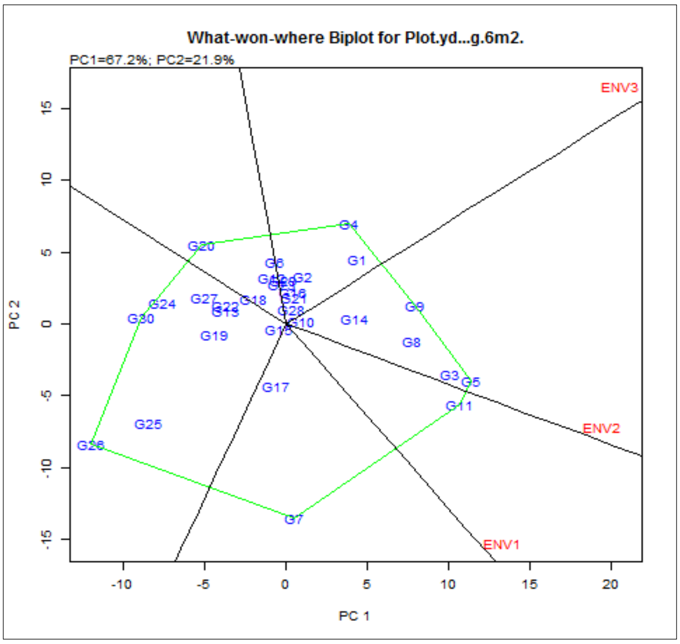

Fig 3: GGE biplot for Plot yield in sesame

Table 1: ANOVA for stability of plot seed yield in sesame genotypes

Sources	df	Days to 50% fl.	No. of branches	No. of capsules	Plot yield
Genotypes	29	12.12*	3.19*	149.12**	3225.7**
Environment	2	191.87**	11.41**	949.38**	5911.0**
G x E	58	3.09**	0.91**	101.78**	843.6**
PCA I	30	4.42**	1.14**	119.88**	1086.9**
PCA II	28	1.66**	0.67**	82.39**	582.9**
Error	89	10.27	1.89	136.25	1733.67

Table 2: Estimates of stability parameters (AMMI model) for days to 50% flowering and number of branches

Genotype no.	Genotypes	Days to flowering			No. of branches		
		Mean	IPCA 1	IPCA 2	Mean	IPCA 1	IPCA 2
G1	COS15013	43.50	-0.29	-0.74	7.833	-0.39	-0.53
G2	COS15016W	42.83	-0.35	-0.44	8.667	0.32	0.87
G3	COS15001	42.83	-0.98	0.87	8.000	-0.14	-0.80
G4	COS15022	42.17	-0.13	-0.64	7.667	0.14	0.73
G5	COS15010	40.83	-0.62	-0.76	8.667	-.044	-0.25
G6	COS15014	41.67	0.47	0.36	9.167	0.52	0.34
G7	COS15023	43.17	-0.12	-0.54	8.833	-0.48	-0.21
G8	COS15020	42.50	0.51	-0.51	8.833	-0.65	0.43
G9	COS15016Br	43.00	0.79	-0.18	7.833	0.68	0.40
G10	COS15003	41.33	0.11	-0.73	10.00	0.27	0.60
G11	COS15011	42.00	0.72	-0.44	9.333	0.67	-0.50
G12	COS15201	43.33	-0.15	-0.38	9.167	-0.35	-0.35
G13	COS15202	43.67	0.54	-0.94	8.500	0.36	0.28
G14	COS15203	44.33	-0.27	0.13	8.833	0.86	-0.24
G15	COS15204	43.33	0.50	0.77	8.833	0.58	-0.17
G16	COS15205	45.50	-0.12	0.26	8.833	0.37	-0.34
G17	COS15206	44.67	0.20	0.42	8.833	0.48	0.15
G18	COS15207	44.50	0.88	0.88	10.17	0.41	-0.23
G19	COS15208	43.00	0.21	0.60	9.167	-0.53	0.29
G20	COS15209	44.33	0.15	0.91	8.833	-0.37	0.36
G21	COS15210	43.83	0.44	0.51	7.167	0.26	-0.67
G22	COS15211	43.17	0.61	0.24	7.333	-0.28	0.36
G23	COS15212	42.17	0.40	0.10	7.500	0.73	0.35
G24	COS15213	42.83	0.58	0.31	8.500	-0.12	0.96
G25	COS15214	43.33	0.60	-0.39	8.000	-0.23	-0.47
G26	COS15215	43.00	0.21	0.60	7.833	-0.94	0.49
G27	COS15216	41.50	-0.80	0.30	7.333	-0.28	0.36
G28	VRI 2	40.67	-0.13	0.53	9.333	-0.19	-0.28
G29	TMV 7	42.00	-0.94	0.49	8.500	0.16	0.26

G30	SVPR 1	33.83	-0.49	-0.25	4.667	0.13	-0.16
	Mean L1	39.93	0.13	0.42	8.07	-0.22	0.34
	Mean L2	43.00	-0.25	0.38	9.10	0.16	-0.47
	Mean L3	44.95	0.31	-0.26	8.00	0.28	0.35
	Grand mean	42.63			8.39		

Table 3: Estimates of stability parameters (AMMI model) for number of capsules and Plot seed yield

Genotype no.	Genotypes	No. of capsules			Plot yield		
		Mean	IPCA 1	IPCA 2	Mean	IPCA 1	IPCA 2
G1	COS15013	97.50	0.39	0.12	957.7	-0.53	-0.18
G2	COS15016W	99.50	-0.14	-0.20	893.5	-0.37	-0.66
G3	COS15001	111.0	-0.15	-0.45	1083.2	0.17	0.36
G4	COS15022	93.67	0.27	0.13	943.2	-0.76	-0.10
G5	COS15010	98.50	0.67	-0.15	1098.4	0.16	-0.35
G6	COS15014	85.67	0.11	-0.19	867.5	-0.41	-0.88
G7	COS15023	99.33	0.14	0.16	922.2	0.13	-0.39
G8	COS15020	91.50	0.27	0.20	1028.1	-0.45	-0.29
G9	COS15016Br	100.7	0.11	0.10	1025.6	-0.29	-0.27
G10	COS15003	103.7	-0.10	0.29	907.8	-0.31	0.11
G11	COS15011	108.2	0.81	0.35	1086.5	0.32	-0.58
G12	COS15201	98.50	-0.19	-0.28	863.3	-0.31	-0.35
G13	COS15202	95.83	-0.88	-0.70	816.8	-0.43	-0.39
G14	COS15203	100.8	-0.27	0.19	972.8	-0.81	0.68
G15	COS15204	105.7	-0.19	0.35	884.3	0.48	0.13
G16	COS15205	101.5	0.80	0.77	895.0	-0.21	0.25
G17	COS15206	104.7	-0.15	-0.86	894.8	0.47	0.61
G18	COS15207	98.67	-0.15	-0.56	851.5	-0.13	0.12
G19	COS15208	98.83	-0.68	-043	821.5	0.19	0.80
G20	COS15209	103.7	-0.24	0.27	791.5	-0.42	0.44
G21	COS15210	99.67	0.15	0.18	897.2	-0.18	0.18
G22	COS15211	97.38	-0.15	0.14	821.5	0.49	0.12
G23	COS15212	104.8	-0.28	0.15	881.8	-0.26	0.21
G24	COS15213	93.83	0.32	-0.78	753.0	0.99	0.25
G25	COS15214	93.33	0.16	-0.64	748.8	0.82	-0.28
G26	COS15215	97.00	-0.11	0.17	693.2	0.10	0.15
G27	COS15216	98.67	-0.13	0.51	800.2	-0.68	0.31
G28	VRI 2	94.17	0.58	-0.92	893.0	-0.11	-0.11
G29	TMV 7	102.0	0.89	-0.99	877.2	-0.31	-0.29
G30	SVPR 1	72.83	0.18	-0.40	725.5	0.10	-0.36
	Mean L1	104.7	0.34	-0.24	938.5	0.42	-0.65
	Mean L2	96.45	0.48	0.30	879.4	0.62	-0.30
	Mean L3	93.95	-0.29	-0.18	851.6	0.66	0.70
	Grand mean	98.37			889.8		

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