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REGULAR ARTICLE

STUDY ON GENOTYPE x ENVIRONMENT INTERACTION OF YIELD IN SESAME (*SESAMUM INDICUM* L.)

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SUMMARY

Seed yield stability of twenty sesame genotypes of different sources of origin were studied for GEI in randomized complete block design with three replications across six environments in 2006. The objectives were to estimate the nature and magnitude of GEI for seed yield, and to identify stable sesame genotypes for general adaptation, Combined analysis of variance showed highly significant ($p<0.01$) difference for the main and interaction effect for the trait studied, suggesting differential response of genotypes across testing locations and the need for stability analysis. Genotypes Tatte, Mehado-80, E, and S gave high mean seed yield of 559.2, 432.0, 363.6 and 348.3 kg/ha, respectively. The lowest seed yield of 170.1 kg/ha was obtained from genotype Abasena. AMMI stability analysis methods were used to further shed light on the GEI of seed yiel. Two IPCA of AMMI were significant ($P<0.01$) and captured the largest portion of variation of the total GEI for the trait studied, which indicated that the AMMI model 2 was the best for the data set. Genotypes Temax (1), Acc 051 02 sel 6 (7), Clusu 5 (13), Kelafo 74 (20), NN 0136 sel 2 (6), Acc 212 332 4 (8), Addi (9), and Acc 051 02 sel 10 (11) were the only genotypes showed relatively little GxE interaction in terms of both IPCA1 and IPCA2 axes and therefore stable. The high-yielding genotypes Tatte, Mehado-80 and E were unstable and specifically adapted to high-yielding environments (Goffa, Arbaminch, and Derashie).

Keywords: Stability, GEI, Genotypes, *Sesamum indicum.*

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1. Introduction

Sesame is an ancient oil seed used by man adapted to tropical regions (Weiss, 2000). As it is a short day plant and sensitive to photoperiod, temperature and prolonged moisture stress, the yield of sesame is not stable and varies widely (Velu and Shunmugavallic, 2005).

A specific difference in environment may have a greater effect on some genotypes than others (Falconer, 1981). When genotypes respond differently to a change in the environment, the phenomenon of Genotype x Environment Interaction (GEI) is said to occur. GxE interactions in general, and GxE interactions of crossover type in particular, are considered to have a negative impact on the success of breeding programs, because breeders search for a few widely adapted cultivars. GEI become important when the rank of breeding lines changes in different environments (Baker, 1988). Because of the interaction, the selection of stable genotypes that interact less with the varying environments in which they are to be grown is required.

Information on the adaptation and stability of the genotypes over seasons and over sites is useful for recommending the varieties that should be grown under particular production environments and predicting the yield expectations of the test varieties (genotypes). A variety or genotype is considered to be the most adaptive or stable one if it has a high mean yield but a low degree of fluctuation in yielding ability when grown over diverse environments (Arshad et al., 2003). A significant portion of the resources of crop breeding is devoted determining GEI through replicated multilocation trial.

Several studies were carried out on GEI throughout the world by different researchers on various oil crops like linseed (Adugna and Labuschagne, 2002), Ethiopian mustard (Kassa, 2002), Sunflower (Ghafoor et a.l, 2005; Dijanovic et al., 2004) and Sesame (Boshim et al., 2003; John et al., 2001), however, there is inadequate information on the stability of improved cultivars and their response to different agro-ecologies.

Variety development and agronomic research in Ethiopia has resulted in the development of high-yielding varieties out of introduced, locally collected and segregating populations using multi-location testing and verification. However, studies on the effects of GEI on sesame are quite few (Yebio et al., 1993) and there is inadequate information on the stability of improved cultivars and their response to different agro-ecologies. Therefore, demonstration of seed yield stability and assessment of the magnitude of the GEI effect in sesame will lead to more efficient allocation of resources in our multi-environmental cultivar testing program.

The present study was an attempt to study the magnitude and nature of G x E interaction of seed yield of sesame genotypes grown at different locations and identify stable genotypes that can give high seed yield under a wide range of growing conditions within Southern Nations, Nationalities, and Peopl's Regional State (SNNPRS).

2. Materials and Methods

The experiment was carried out at six environments of Southern Ethiopia during the 2006 cropping season (July to December). These locations are situated within the altitudinal ranges of 1250 to 1400 m.a.s.l, have soil characteristics of Sandy clay loam, Clay, Clay loam, Sandy clay, Silt clay and Sandy loam and are the main variety testing sites for lowland oil crops of Southern Agricultural Research Institute (SARI). Twenty sesame genotypes, ten released varieties and ten elite lines, were used in the study. The experiment was laid out in a randomized complete block design with three replications in each environment. The unit plot size in a replication measured 5 m in length and 2 m in width accommodating 5 rows of 250 plants per genotypes after thinning keeping row to distance 0.4 m and plant to plant distance 0.1 m. Normal cultural practices were followed. Data on various characters were recorded, but only seed yield is considered and presented in this paper. Analysis of variance was undertaken for the combined analysis of variance across the test environments. Following testing of the significance of the GEI mean square, means over three replications for seed yield of genotype i at location j $\overline{Y_{ij}}$ were subjected to AMMI stability analysis using SAS (Hussien et al., 2000) and

Agrobase 2000TM (Agrobase, 2000). AMMI's stability value (ASV) was calculated using the following formula, as suggested by purchase (1997).

$$ASV = \sqrt{\left[\frac{IPCA1sumofsquares\left(IPCSA1score\right)}{IPCA2sumofsquares}\right]^2 + \left(IPCA2score\right)^2}$$

Where, ASV = AMMI's stability value, SS = sum of squares, IPCA1 = interaction of principal component analysis one, IPCA2 = interaction of principal component analysis two.

3. Results and Discussions

Analysis of variance and estimation of variance component for seed yield

The mean seed yield of sesame genotypes averages over environments is presented in Table 1. The mean seed yields at the individual environments ranges from 32.4 kg/ha at Kucha to 617.8 kg/ha at Goffa. This difference was mainly because of the wide range of environmental factors mainly amounts precipitation, temperature and soil types (edaphic factors). Goffa had the largest environmental index of 306.9 and therefore the most suitable environment for higher seed yield. On the other hand Kucha recorded the least environmental index of -278.6 and hence the poorest environment.

Table 1. Environmental mean seed yield (kg/ha), IPCA scores and index of sesame genotypes tested at six locations.

Environment	Environmental Index	Environment Mean (kg/ha)	IPCA1	IPCA2
Goffa	306.9	617.8	5.5576	16.5193
Kucha	-278.6	32.4	-13.3943	-4.1013
Bedessa	-108.1	202.8	-2.6975	4.5814
Arbaminch	195.0	506.0	3.8503	-1.6298
Derashie	97.8	408.7	16.9581	-10.5030
Amarokele	-213.0	97.9	-10.2743	-4.8667

The result from the combined analysis of variance (ANOVA) for seed yield is shown in Table 2. The effects due to environment, genotype and GEI were highly significant ($P<0.01$) leading to extension of analysis for estimating stability parameters. This result is in conformity with the findings of Adugna and Labuschagne (2003) in linseed. They reported variation relative to environments, genotypes, and their interaction was highly significant. Partitioning of the variance components indicated that 68.1% was due to environment, 4.9% due to block, 6.6% due to genotype, 5.0% due to GEI and 15.6% due to error (Table 2). The large proportion of variance due to environment and low but close contributions of variance due to genotype and GEI indicates the significant influence of environment in evaluation of sesame genotypes for yield performance in South Ethiopia. Similarly large contribution of environment was also reported by Boshim et al. (2003) in which they indicated that environments accounted for the largest proportion (91%) followed by GEI (8%) and genotypes (1%).

Additive Main Effects and Multiplicative Interaction (AMMI)

The AMMI analysis of variance is given in Table 3. Results from AMMI analysis showed that the first principal component axis (IPCA 1) of the interaction captured 51.47 % of the interaction sum of squares with 23 degree of freedom. Similarly, the second principal component axis (IPCA 2) explained a further 26.33 % of the GEI sum of squares. The mean squares of both IPCA 1 and IPCA 2 were significant at $P = 0.05$ and cumulatively contributed 77.8% of the total GEI. This result indicates that the AMMI model fits the data well, and justifies the use of AMMI2.

Variability in both main effects and interaction (IPCA 1) of environments and genotypes for mean seed yield is shown in

Figure 2. Environment Goffa (A) was the most favourable for all genotypes where maximum mean seed yield was recorded. Environment Arbaminch (D) and Derashie (E) also showed suitability for performance of all genotypes where high mean seed was obtained. Kucha (B) and Amarokele (F) were the least favourable environments for the performance of all genotypes and the lowest mean seed yield was recorded at these locations.

Table 2. The analysis of variance table for AMMI of seed yield for the 20 sesame genotypes tested over 6 environments

Source of Variation	DF	SS	% SS	MS	F-value	Pr>F
Total	359	24968567.58				
Environments	5	16587118.88	66.40	3317423.78**	36.96	0.0000
Reps within Env.	12	1077160.52	4.30	89763.38		
Genotype	19	2236463.28	9.00	117708.59**	4.90	0.0000
Genotype x Env.	95	2280245.57	9.10	24002.59**	1.96	0.0000
IPCA 1	23	1173667.36	51.47	51029.02**	4.17	0.0000
IPCA 2	21	600320.58	26.33	28586.69**	2.34	0.0012
IPCA 3	19	369917.64	16.22	19469.35	1.59	0.0592
IPCA 4	17	104147.25	4.57	6126.31	0.50	0.9510
IPCA 5	15	32192.75	1.41	2146.18	0.18	0.9998
Residual	228	2787579.34		12226.23		

Grand mean = 310.93 R-squared = 0.89 C.V. = 35.56 %

** = significance at $P<0.05$.

Table 3. AMMI Stability value (ASV) and ranking with the IPCA 1 and 2 scores of yield for the 20 genotypes tested at six locations.

Entry	Entry Name	Mean yield	VIPC1	VIPC2	ASV	Rank
1	Temax	286.7	-0.7071	1.3228	1.9133	1
2	NN 0048	232.8	-2.4525	10.4095	11.4607	17
3	E	363.6	3.0468	7.8449	9.8501	15
4	Mehado 80	432.0	8.2379	-3.9078	16.5730	19
5	Argane	339.7	3.0361	6.4258	8.7478	13
6	NN 0136 sel 2	246.9	-4.0431	-0.0206	7.9046	9
7	Acc 051 02 sel 6	301.5	-2.5043	1.0705	5.0117	5
8	Acc 212 332 4	310.3	1.5204	-1.8041	3.4771	3
9	Addi	285.7	-2.8715	-1.7918	5.8930	6
10	Tatte	559.2	19.0703	-2.8747	37.3944	20
11	Acc 051 02 sel 10	297.6	-4.0335	-1.0812	7.9595	10
12	T 6P 32 3	285.8	-3.2511	-5.8974	8.6706	12
13	Clusu 5	267.7	-1.137	2.3834	3.2591	2
14	SPS SIK 98	274.5	-4.2794	-4.0325	9.2876	14
15	NN 0089 (3)	232.5	-5.1131	-4.1032	10.8058	16
16	S	348.3	-1.7975	-5.3633	6.4121	7
17	Abasena	170.1	-7.0204	2.4064	13.9347	18
18	T 85	312.6	2.8192	4.6537	7.2136	8
19	Serkamo	346.8	-0.1553	-8.1305	8.1362	11
20	Kelafo 74	324.5	1.6351	2.4902	4.0522	4

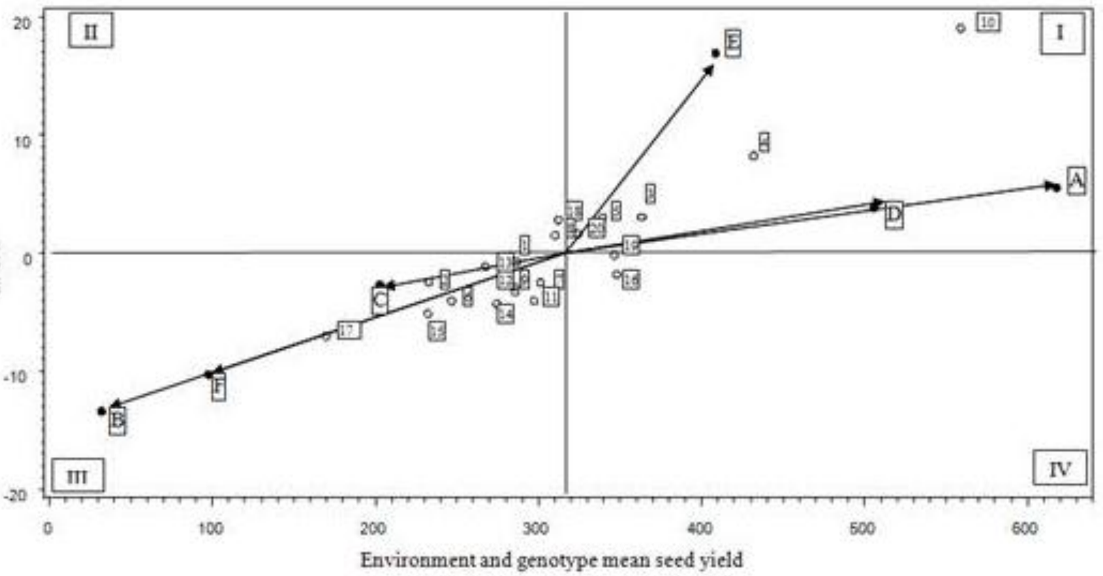

Figure 1. IPCA1 scores for environments plotted against the environment and genotype mean (kg/ha)
A = Goffa; B = Kucha; C = Bedessa; D = Arbaminch; E = Derashie; F = Amarokele; 1 = Temax; 2 = NN-0048; 3 = E; 4 = Mehado-80; 5 = Argane; 6 = NN-0136-Sel-2; 7 = Acc-051-02-Sel-6; 8 = Acc-212-332-4; 9 = Addi; 10 = Tatte; 11 = Acc-051-02-Sel-10; 12 = T-6P-32-3; 13 = Clusu-5; 14 = SPS-SIK-98; 15 = NN-0089 (3); 16 = S; 17 = Abasena; 18 = T-85; 19 = Serkamo; 20 = Kelafo-74.

As indicated in Figure 1, environment Goffa (A), Arbaminch (D), and Derashie (E) showed similarity in interaction and suitability for the performance of genotypes Tatte (10), Mehado-80 (4), E (3), Argane (5), Serkamo (19), Kelafo-74 (20) and T-85 (18) in seed yield. Similarly environments Kucha (B), Amarokele (F), and Bedessa (C) showed similarity in response to interaction and shows suitability for the performance of genotypes Abasena (17), NN-0089 (3) (15), NN-0136-Sel-2 (6), NN-0048 (2), SPS-SIK-98 (14), Clusu-5 (13), T-6P-32-3 (12), Addi (9), Acc-051-02-Sel-10 (11), Acc-051-02-Sel-6 (7), and Temax (1).

According to IPC 1 score, genotypes that are concentrated around the origin were considered as stable. As shown on the Fig. 1, genotypes Argane (5), Serkamo (19), Kelafo-74 (20) and S (16) were stable with high yield and genotypes T-85 (18), and Acc-212-332-4 (8) were stable with average yield. Genotypes Temax (1), Acc-051-02-Sel-6 (7), Clusu-5 (13), Addi (9), T-6p-32-3 (12) and Acc-051-02-Sel-10 (11) and NN-0136-Sel-2 (6) were stable and low yield; genotype Abasena (17) was unstable and low yielder. From the tested genotypes Tatte (10), E (3) and Mehado-80 (4) were unstable and high yielder, however, these genotypes shown high performance to environments Goffa (A), Arba Minch (D) and Derashie (E).

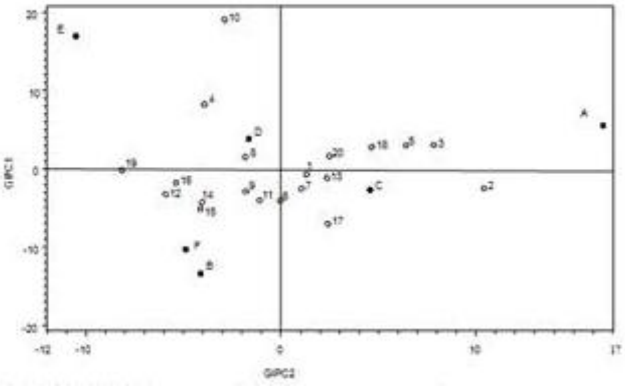

Figure 2. The IPCA 1 AND IPCA2 scores plotted for sesame genotypes
A = Goffa; B = Kucha; C = Bedessa; D = Arba Minch; E = Derashie; F = Amaro Kele; 1 = Temax; 2 = NN-0048; 3 = E; 4 = Mehado-80; 5 = Argane; 6 = NN-0136-Sel-2; 7 = Acc-051-02-Sel-6; 8 = Acc-212-332-4; 9 = Addi; 10 = Tatte; 11 = Acc-051-02-Sel-10; 12 = T-6P-32-3; 13 = Clusu-5; 14 = SPS-SIK-98; 15 = NN-0089 (3); 16 = S; 17 = Abasena; 18 = T-85; 19 = Serkamo; 20 = Kelafo-7

If however IPCA2 is also taken in to consideration, Fig. 2, genotypes Tatte (10), NN 0048 (2), E (3), Mehado 80 (4), Argane (5) and Serkamo (19) show considerably more GxE interaction due to the factor or factors explained by IPCA2. Temax (1), Acc 051 02 sel 6 (7), Clusu 5 (13), Kelafo 74 (20), NN 0136 sel 2 (6), Acc 212 332 4 (8), Addi (9), and Acc 051 02 sel 10 (11) were the only genotypes showed relatively little GxE interaction in terms of both axes and therefore stable.

AMMI Stability Value (ASV)

Quantitative stability measure is essential in order to quantify and rank genotypes according to their yield stability. However, the AMMI model does not provide measure for a quantitative stability. For this ASV was proposed by Purchase (1997). Table 3 indicates the AMMI model IPCA 1 and IPCA 2 scores and ASV of seed yield for each genotype. According to the ASV ranking the following genotypes were the most stable: Temax, Clusu-5, Acc-212-332-4, Kelafo-74, and Acc-051-02-Sel-6. Among these genotypes, all but Kelafo-74 are elite lines. The most unstable genotypes were: Tatte, Mehado-80, Abasena, and NN-0048 and the first three have been released varieties for production.

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