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Genotype x Environment and Stability Analysis of Oil Content in Sesame (*Sesamum indicum* L.) Evaluated Across Diverse Agro-ecologies of the Awash Valleys in Ethiopia

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Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study and wrote the first draft of the manuscript. Author FM reviewed the experimental design and all drafts of the manuscript. Authors AA and MN managed the analyses of the study. Author MA managed the literature searches and correction of the manuscript. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Aim: To estimate the nature and magnitude of GEI interaction for oil content in sesame varieties and to identify stable and promising varieties for general and specific adaptations across the areas of the Awash valleys in Ethiopia.
Study Design: Entries were planted in a randomized complete block design (RCBD) replicated thrice in each location and year.

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Place and Duration of Study: The study was conducted at Assaita, Melkassa and Werer representing the Lower, Upper and Middle Awash valleys of Ethiopia respectively, during the 2010/11 main cropping season and 2011/12 off season.
Methodology: Morphological data taken from each environment were analyzed for combined analysis of variance, Additive Main Effects and Multiplicative Interaction (AMMI), Biplot analysis, AMMI Stability Value (ASV), and regression analysis. Finally, ranking of genotypes was done based on the overall results of all stability indices.
Results: Combined analysis of variance showed highly significant ($P<0.01$) difference between the varieties, environments and GEI, suggesting differential response of varieties across testing environments and the need for stability analysis. Proportion of variance captured by environments was 1.43%, genotypes 91.5% and GEI 7.1% of the total variation, indicating less effect of environments on oil content as compared to the effect of genotypes. Stability analysis by AMMI and Joint-regression model were used to further shed light on the GEI of oil content. Two IPCA of AMMI were significant ($P<0.01$) and captured the largest portion of variation of the total GEI, which indicated that the AMMI model was the best for the data set. The Joint regression analysis indicated that the linear regression (bi) did not deviate from unity for all varieties, suggesting that performance of the cultivars could not be predicted in a linear manner.
Conclusion: The influence of environment is less prominent in the manifestation of oil content along the areas of Awash valleys. Season two is the best environment for growing the present set of genotypes for oil content. Variety Adi was identified as the most stable variety across environments for oil content. This variety can be recommended for varied environments of the Awash valleys to exploit its yield potential. The rest high yielder varieties, Serkamo, Tate and Argene can be adapted only under favorable environmental conditions.

1. INTRODUCTION

The adaptability of a variety over diverse environments is usually tested by its degree of interaction with different growing environments. A variety or genotype is considered to be more adaptive or stable if it has a high mean yield but low degree of fluctuation in yielding ability when grown over diverse environments [1]. Failure of genotypes to respond consistently to variable environmental conditions is attributed to Genotype x Environment Interaction (GEI). Knowledge of GEI is advantageous to have a cultivar that gives consistently high yield in a broad range of environments and to increase efficiency of breeding program and selection of best genotypes.

Seed oil content can vary considerably between cultivars and seasons. Weiss [2] stated that cultivars grown at numerous sites in the USA showed a significant sesame cultivar by location interaction of oil content. A study on oil yield of sunflower for stability and adaptability at eight locations in Pakistan indicated that the GEI contributed about 85.45% of total variation, which is an indication that a stability analysis of genotypes with respect to oil yield based on location index was important [3]. Several other studies were carried out on GEI of oil content throughout the world by different researchers on

various oil crops like linseed [4,5], sunflower [3,6], Ethiopian mustard [7] and sesame [8-10].

Several methods have been proposed to analyse GEI or phenotypic stability. These methods can be divided into two major groups, univariate and multivariate stability statistics. Joint- regression is the most popular among univariate methods because of its simplicity of calculation and application [11], whereas Additive Main Effect and Multiplicative Interaction (AMMI) is a multivariate approach, gaining popularity and is currently the main alternative to joint-regression model in many breeding programs [12]. It is widely used for G x E investigation of multi environment cultivar traits [13,14].

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 [15]. A considerable variation in oil content is observed on released varieties and elite genotypes of sesame under trial across locations. However, studies on the effects of GEI on sesame oil content in Ethiopia are quite few [16]. Assessing any genotype performance without including its interaction with the environment is incomplete and limits the accuracy of measured parameter estimates.

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Therefore, this paper is designed to study the magnitude and nature of G x E interaction for oil content of sesame varieties grown at different environments and to identify stable genotypes that can give high seed yield with high oil content under a wide range of growing conditions across the Awash valleys in Ethiopia.

2. MATERIALS AND METHODS

2.1 Description of Study Areas

The experiment was conducted at 3 locations across the Awash valley called Assaita, Melkassa and Werer (Table 1, Fig. 1).

2.2 Planting Materials

Ten released varieties of sesame (Table 2) were evaluated for performance of yield and oil content at each site over two different seasons during the 2010/11 main cropping and 2011/12 off seasons.

2.3 Field Layout and Data Collection

The experiment at each location was laid-out in a randomized complete block design with 3 replications. Each entry was planted in a plot having 4 rows of 4 m long with 40 x 10 cm spacing between rows and within plants respectively. Data on various characters were recorded, but only oil content was considered and presented in this paper. Oil content for individual variety was determined by extracting the ground seed in a Soxhlet apparatus with petroleum ether. Oil content in percent (OC%) was measured by Nuclear Magnetic Resonance Spectroscope (NMRS) as the proportion of oil in the seed to the total oven dried seed weight x (100) [17].

Table 1. Characteristics of the study sites

Location	Altitude (m.a.s.l.)	Latitude/Longitude	Rainfall (mm)	Tempert (^{0}C)	Soil type	pH
Melkassa	1550	8°33' N 39°17' E	560	15.2 - 27.5	Verti-cambisol	7.4
Werer	740	9°60' N 40°9' E	450	19.5 - 32.5	Fluvisol & Vertisol	8.4
Ayssaita	350	11°33' N 40°41' E	250	23.8 - 37.5	Chromic-Lithosol	6.2

Fig. 1. Maps locating the study areas: Upper, middle and lower awash valleys in Ethiopia

Table 2. Sesame varieties used in the study

No.	Varieties	Codes	Pedigree	Seed color	Mean oil content*	Released year (GC)
1	Abasena	Abs	SPSBIMSEL	Grey	40-48%	1993
2	S	S	SPS111872	Mixed (dark/br)	40-46%	1990
3	Kalafo-74	Klf	SPS111866	Light brown	42-46%	1989
4	ADI	Adi	X-3014	White	53-65%	1993
5	Serkamo	Srk	BIMW205196	Mixed (white/br)	45-50%	1993
6	Mehado-80	M80	SPS111518	Grey	41-44%	1989
7	Tate	Tat	BCS-003	Light gray	47-49%	2000
8	T-85	T85	SPS111868	Dull white	42-45%	1976
9	E	E	SPS111853	Dull white	42-46%	1978
10	Argene	Arg	T-85xCROSS	Mixed	42-49%	2000

* Source = Ethiopian Institute of Agricultural Research (EIAR), 2007

2.4 Data Analysis

To evaluate the interaction effects, the data were subjected to multivariate analysis using additive main effect and multiplicative interaction (AMMI) model as previously described by Gauch et al. [18]. The mathematical statement of AMMI model is given by the following formula:

$$Y^N_{\iota\varphi} = \mu + g_i + e_j + \Sigma\lambda_\kappa\Psi_{\iota\kappa}\alpha_{\varphi\kappa} + \Sigma_{\iota\varphi}$$

Where; Y_{ij} = yield of ith genotype in the jth environment, μ = grand mean, g_ie_j = genotype and environment deviations from the grand mean, λ_k = eigen value of PCA axis k, Y_{ik} and α_{jk} = genotype and environment PCA scores for axis k, N = number of IPCs, Σ_{ij} = residual term.

The results of AMMI analysis were shown in common graphs called biplots as described by Gauch and Zobel [19], which provides a clear insight into specific GEI combination and the general pattern of adaptation of genotypes. The AMMI biplot was done by placing both genotype and environment values on the abscissa (X- axis) and the respective PCA scores, Eigen vector on the Y- axis. AMMI model does not make provision for a specific stability measure to be determined. Since the IPCA1 score contributes more to G x E sum of squares, a weighted value is needed in order to rank genotypes in terms of stability. Hence, AMMI stability value (ASV) was calculated based on the formula proposed by Purchase [20]:

$$ASV = \{[(SSpca1/SSpca2)\,(GPCA1\text{ score})]^2 + (GCPA2\text{ scores})\}^{\frac{1}{2}}$$

Where; ASV = the distance from zero in a two dimensional scatter gram of IPCA 1 against IPCA 2 scores; SSpca1/SSpca2 = the weight given to the PCA1 value by dividing the PCA1 sum of squares to the PCA2 sum of squares; GPCA1 score = the PCA1 score for that specific genotype and GPCA2 = the PCA 2 score for that specific genotype.

The data were also subjected to regression analysis using a model proposed by Eberhart and Russell [21]. The regression of each genotype in each environment on an environmental index and a function of the squared deviations from its regression would provide estimates of stability parameters: the regression coefficient (b_i) and mean square deviations from linear regression (S^2d_i). The mean sum of squares due to GEI was tested against pooled error. The pooled deviation was also tested against pooled error. The results from both analyses were compared and are presented in Table 5.

3. RESULTS AND DISCUSSION

3.1 Pooled Analysis of Variance for Oil Content

The combined analysis of variance for oil content of ten sesame varieties tested in 6 environments showed that the variance for genotypes, environment and G x E interaction were highly significant at *P < 0.01* (Table 3), indicating rank difference in varieties response to different environments and the need for extension of stability analysis. This result confirmed the results reported by Adane [5] and Mekonen [22]. Weiss [2] also found a significant GEI where a 6% variation for oil content was due to location. The partitioning of variance components indicated that 91.48% of the total variation was due to genotypes, 1.43% due to environments,

1.50% due to replications within environments, 7.10% due to GEI and 6.33% due to residual (Table 3). The higher proportion of variance due to genotypes more than environments indicated that the effect of environment on oil content was not large. Similar results were recorded on sesame oil content by Alpaslan et al. [23], Zenebe and Hussien [10] and Mekonen [22].

3.2 AMMI Analysis

The portioning of GEI components (Table 3) showed that the first principal component axis IPCA1 of the interaction captured 75.1% of the interaction sum squares. Similarly, IPCA2 explained a further 18.5% of the GEI sum of squares. The mean squares (MS) for IPCA1 and IPCA2 were significant at *P < 0.01* and cumulatively contributed to 93.6% of the total GEI. The partitioning of the interaction sum of squares was effective for oil content. The MS of IPCA1 and IPCA2 were 19x and 5.5x that of the residual MS respectively. The combined MS for the two IPCA axes were 24.5 times that of the residual MS for oil content. Therefore, this result suggested that the two interaction principal component axes were sufficient to explain GEI in oil content. This result was in harmony with some of the previous findings [10,24]. They indicated that AMMI with only two interaction principal component axes was the best predictive model. Similar results were also reported by Molla [25] in finger millet and Nigussie [26] in common bean.

The mean oil content averaged over environments is presented in Table 4. The mean oil content for the individual environments ranged from 48.03% at Ml. 1 (Melkassa season-1) to 48.56% at Wr. 2 (Werer season-2). This difference was mainly due to their varying amounts of temperature and soil type, which differed greatly across locations and seasons. A similar result was reported by Abou El-Nasr *et al*. [27], they indicated that a change in season and soil type caused variation in oil content of white mustard. Wr. 2 had the largest environmental index and therefore the most suitable environment for realizing oil content potential of sesame varieties across the areas of the Afar rift valley.

3.3 Biplot Analysis

Fig. 2 represents the AMMI biplot for oil content of sesame varieties grown in six environments. The mean performance and PCA1 scores for both the genotypes and environments used to construct the biplots are presented in Table 4. In AMMI biplot presentation, when a variety and environment have the same sign on PCA1 axis, their interaction is positive and if different their interaction is negative. If a variety or an environment has a PCA1 score of nearly zero, it has small interaction effects and was considered as stable over wide range of environments. However, varieties with high mean performance and large PCA1 scores were considered as having specific adaptability to favourable environments.

As shown in Fig. 2, the varieties and environments showed considerable variation in mean oil content. However, it is clear from the graph that the points for varieties were more scattered than the points for environments indicating that variability due to varieties was higher than that due to environments, which is in complete agreement of the ANOVA (Table 3). Generally, season two showed the highest mean performance for oil content across all locations (Table 4).

Table 3. AMMI analysis of variance for oil content (%) in 10 sesame varieties tested at three locations for two different seasons (2010/11 & 2011/12)

Sources of variation	Degree of freedom	Mean square	F-value	Total S.S. explained (%)
Genotype	9	113.15**	233.39	91.48
Environment	5	3.18*	2.28	1.43
Rep within Env.	12	1.40**	2.88	1.50
G X E	45	1.75**	3.62	7.10
IPCA 1	13	4.56**	9.41	75.06
IPCA 2	11	1.32**	2.73	18.48
Residuals	21	0.24	0.5	6.33
Error	108	0.48	-	4.43
Total	179	6.60	-	100
Grand Mean = 48.16				CV (%) = 1.5

***, * = highly significant at p< 0.01 and p< 0.05 level respectively.*

Table 4. AMMI analysis of genotype and environment means, IPCA 1 scores for oil content of sesame varieties tested at three locations and two seasons (2010/11 and 2011/12)

Genotype	2010/11 Cropping season			2011/12 Off season			Genotype	
	Melkasa	**Werrer**	**Assaita**	**Melkasa**	**Werrer**	**Assaita**	**Mean**	**IPCA 1**
Abs	46.50	46.80	45.80	46.67	46.27	46.90	46.49	0.003
Adi	51.93	52.80	52.80	52.10	52.80	53.50	52.66	-0.486
Arg	49.77	49.67	48.57	50.40	51.33	48.67	49.73	0.240
E	47.27	46.80	46.17	47.47	46.80	46.43	46.82	0.432
Klf	47.20	46.33	46.60	47.73	46.73	46.67	46.88	0.514
M80	46.77	45.33	45.47	47.30	45.90	45.67	46.07	0.774
S	46.57	45.57	46.27	46.73	46.00	45.83	46.16	0.506
Srk	50.03	51.87	50.67	50.07	52.13	52.23	51.17	-0.994
T85	46.00	45.00	44.83	46.10	45.97	45.53	45.57	0.334
Tat	48.30	50.60	49.10	49.03	51.70	51.57	50.05	-1.322
Env. Mean	48.03	48.08	47.63	48.36	48.56	48.30	48.16	
IPCA 1	1.134	-0.643	0.070	1.125	-0.674	-1.012		

Note: IPCA1 = Principal component axis one, Env. mean = environmental mean

Plot of Gen & Env IPCA 2 scores versus means
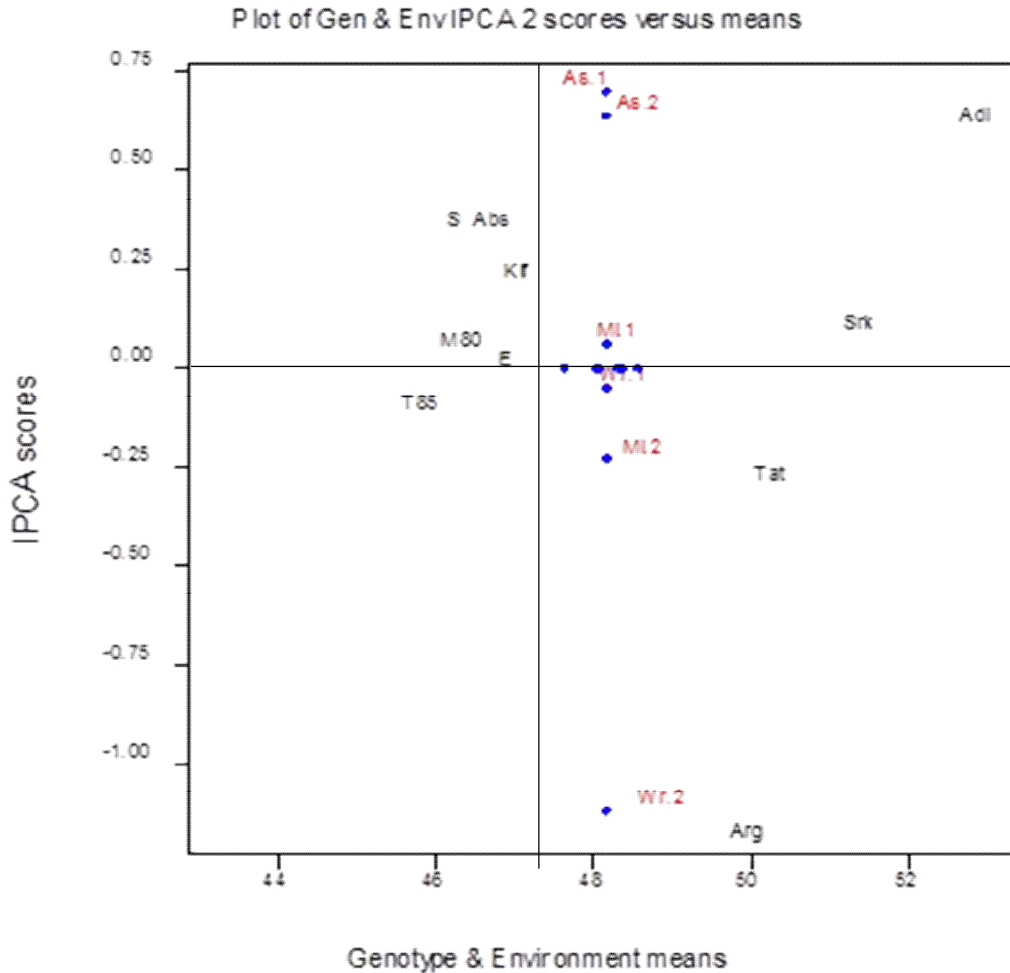
Fig. 2. AMMI biplot for oil content (%)
*As.1 =Assaita season-I, As.2 =Assaita season-II, Ml.1 =Melkassa season-I, Ml.2 =Melkassa season-II,
Wr.1 = Werer season-I, Wr.2 = Werer season-II*

Table 5. AMMI stability value and ranking with PCA 1 and 2 scores of oil content (%) for 10 sesame varieties tested at 3 locations and two seasons (2010/11 and 2011/12)

Variety	Mean	MnR	PCA1	PCA2	ASV	R
Abs	46.49	7	0.003	0.343	0.34	1
Adi**	52.66	1	-0.486	0.607	0.42	2
Arg*	49.73	4	0.240	-1.202	1.20	6
E	46.82	6	0.432	-0.008	3.17	8
Klf	46.88	5	0.514	0.212	0.83	5
M80	46.07	9	0.774	0.042	3.34	9
S	46.16	8	0.506	0.341	0.70	4
Srk*	51.17	2	-0.994	0.083	3.44	10
T85	45.57	10	0.334	-0.120	0.54	3
Tat*	50.05	3	-1.322	-0.298	2.80	7
Grand Mn	48.16					

**, * = wide adaption and specific adaption respectively, MnR= mean rank, PCA1 and 2= the 1st and 2nd Principal components, R= rank of AMMI stability value

As indicated in the biplot graph, the environments As. 2, Ml. 2 and Wr. 2 had the same main effects but highly varied in their interaction effects. Wr.1 had very little interaction (nearly zero) effects with mean oil content close to the grand mean value. Hence, this environment is considered as stable for oil content, whereas As. 1 and Wr.2 were highly interactive having high interaction effects. The varieties Serkamo, Tate and Adi were specifically adapted to favourable environments for oil content (Fig. 2). Of these varieties, Serkamo exhibited little interaction effect because of the relatively smaller distance from the coordinates to the abscissa and was considered as stable across environments with higher mean oil content. However, Adi had the highest mean oil content with a relatively high interaction effects; hence, it is best suited in As. 2. Similarly, Argene was the most interactive and unstable variety in most environments except it showed better adaptation in Wr.2 with high mean performance. On the other hand, varieties E, M-80 and T-85 were adapted to lower yielding environments and stable with low oil content. However, the rest varieties Abasena, S and Kelafo-74 scored mean oil content below the grand mean with different interaction effects and hence they are unstable or not adaptable to any of the environments for oil content.

3.4 ASV Analysis

Table 5, presents the AMMI stability value (ASV) and ranking with PCA 1 and 2 scores for each sesame variety. In ASV method, a variety with high pooled mean and least ASV score is the most stable [28]. Accordingly, the variety Adi was considered as the most stable across all environments. In contrast, Serkamo, Tate and Argene found to have large ASV and high mean performance. These varieties are generally suited to specific environments, which was in accordance with the result of AMMI biplot. However, the remaining varieties, whatever ASV rank they had, since they exhibited below the average performance, were not considered to any environment for oil content. In sesame oil content [10], in soybean [24], in winter oil seed [29], in safflower oil content [30] and in rape seed oil content [31], also conducted AMMI analysis and predicted the stability of genotypes on the basis of mean performance and magnitude of IPCA scores.

3.5 Joint Regression Analysis

The result of ANOVA for the estimated stability parameters for average oil content of varieties is given in Table 6. The mean squares for all sources of variation were highly significant at ($P<0.01$) indicating that the varieties differed from each other with respect to their linear response and prediction of performance in different environment was possible for oil content. The same results were reported in oil content of linseed [5], sesame [22] and soybean [32]. Significant value of pooled deviations indicated the importance of non-linear components for oil content (Table 6). Similar findings were reported by Henry and Daulay [33], Verma and Mahto [34] and Singh et al. [35].

Eberhart and Russell [21] defined a stable variety as the one which showed high mean yield, regression coefficient (b_i) around one and deviation from regression (S^2d_i) near to zero. Accordingly, the mean and deviation from

regression of each varieties were considered for stability and linear regression was used for testing the varietal response as: i/ genotypes with high mean, b_i = 1 and non-significant S^2d_i are suitable for general adaptation, *i.e.*, adaptable over all environmental conditions and they are considered as stable genotypes, ii/ genotypes with high mean, $b_i > 1$ with non-significant S^2d_i are considered as below average instability. Such genotypes tend to respond favourably to better environments but give poor yield in unfavourable environments. Hence, they are suitable for favourable environments, iii/ genotypes with high mean, $b_i < 1$ with non-significant S^2d_i do not respond favourably to improved environmental conditions and hence, they could be regarded as specifically adapted to poor environments, iv/ genotypes with any b_i value and significant S^2d_i are unstable.

The mean oil content (%), regression coefficient (b_i) and the deviation from regression (S^2d_i) of each variety are presented in Table 7. This analysis revealed that the slope (b_i) did not deviate from unity for all varieties, indicating that the tested varieties had average responsiveness to changing environments. However, the deviation from regression (S^2d_i) was significantly different from zero in some of the varieties (Srk, M-80 and Tat). Similar results were reported by Kenga et al. [36] and Fekadu et al. [37], where the non-linear responses as measured by pooled deviations from regressions were highly significant; indicating that differences in linear

response among varieties across environments did not account for all the G x E interaction effects and therefore, the fluctuation in performance of varieties grown in various environments was not fully predictable.

Thus, according to this model the variety Adi had the highest mean oil content (52.7%) with b_i equal to one and insignificant S^2d_i hence, it could be regarded as stable for oil content across environments. This was in accordance with the result of ASV analysis. Argene was the second stable genotype closely followed by Adi, which had high oil content (49.73%) over the grand mean with non-significant b_i and S^2d_i. In contrast, the two high yielder varieties, Serkamo and Tate showed highly significant S^2d_i values and they were regarded as unstable varieties for oil content. On the other hand, varieties Abasena, Kelafo and E had mean oil content values closer to the grand mean with b_i around unity and non-significant S^2d_i. These varieties can be characterized as stable with moderate yield performance (Table 7). This result was in the contrary with the result of the AMMI biplot.

3.6 Ranking of Varieties Based on Stability Parameters

Table 8 presents the ranking orders of ten sesame varieties for oil content, based on the different stability indices. Based on this measurement, a variety that exhibits a high mean

Table 6. Analysis of variance for the estimated stability parameters for average oil content (%) by Ebrehart and Russel's model

Source of variation	DF	MS	F- value
Genotypes	9	37.717**	196.443
Environment (linear)	1	5.297**	27.589
Genotypes X Env. (linear)	9	0.411**	2.141
Pooled deviation	40	0.566**	2.948
Abs	4	0.150	-0.220
S	4	0.246	0.282
Klf	4	0.292	0.524
Adi	4	0.399	1.081
Srk	4	1.114**	4.806
M80	4	0.693**	2.608
Tat	4	1.712**	7.920
T85	4	0.176	-0.085
E	4	0.237	0.237
Arg	4	0.636	2.316
Pooled error	120	0.192	-

*** = highly significant at p< 0.01, MS = mean square*

Table 7. Stability parameters for average oil content (%) by Ebrehart and Russel's model

Variety	Pooled mean	b_i	S^2d_i	F-value (S^2d_i/PE)	t - value (b_i/SEb_i)
Abs	46.49	0.649	-0.042	-0.220	0.530
S	46.16	-0.103	0.054	0.282	-0.066
Klf	46.88	0.446	0.101	0.524	0.261
Adi	52.66	0.128	0.207	1.081	0.064
Srk	51.17	1.267	0.922**	4.806	0.380
M80	46.07	0.785	0.501**	2.608	0.298
Tat	50.05	2.562	1.520**	7.920	0.619
T85	45.57	1.221	-0.016	-0.085	0.920
E	46.82	0.681	0.045	0.237	0.442
Arg	49.73	2.365	0.444	2.316	0.938
Grand Mean	48.16				

** = significant at p< 0.01, bi = regression coefficient, S^2d_i = deviation from regression, PE = pooled error, SEb_i = standard error b_i.

Table 8. Ranking order of sesame varieties for oil content (%) based on the different stability parameters

Genotype	Mean	R	b_i	R	S^2d_i	R	ASV	R	OR
Abs	46.49	7	0.649	5	-0.042	2	0.34	1	1
S	46.16	8	-0.103	8	0.054	4	0.70	4	7
Klf	46.88	5	0.446	6	0.101	5	0.83	5	4
Adi	52.66**	1	0.128	7	0.207	6	0.42	2	2
Srk	51.17*	2	1.267	3	0.922	9	3.44	10	6
M80	46.07	9	0.785	1	0.501	8	3.34	9	9
Tat	50.05*	3	2.562	10	1.520	10	2.80	7	10
T85	45.57	10	1.221	2	-0.016	1	0.54	3	3
E	46.82	6	0.681	4	0.045	3	3.17	8	5
Arg	49.73*	4	2.365	9	0.444	7	1.20	6	8
Gr. Mean	48.16								

**, * = selected for wide adaptation and specific adaptation respectively, ASV = AMMI stability value, R= rank, OR = overall rank

with low overall ranking value was considered as the most stable variety for oil content across all environments. Whereas, those varieties having high mean performance with large overall ranking values were considered to have specific adaptation in favourable environments for oil content. Accordingly, the variety Adi exhibited highest mean value with low overall rank (OR) which is the most stable variety for oil content and adaptable over all environments.

Varieties *viz.*, Serkamo, Tate and Argene expressed higher mean oil contents (51.9, 50.05 and 49.73 %), respectively, but since they were highly interactive with changing environments, they had high overall rank values. Therefore,

these varieties can be selected for specific environments with high mean performance. On the other hand, Abasena, Kelafo and E were medium yielding varieties with ranking orders of 1st, 4th and 5th, respectively; hence, they are considered to have better response to unfavourable environments for oil content. However, the remaining varieties S, M-80 and T-85 gave lower mean oil contents of 46.16, 46.07 and 45.57 %, respectively that were below the grand mean value. Hence, they are regarded as poorly responsive and unstable varieties over all environments for oil content (Table 8). This result was in complete agreement with the above findings of AMMI stability value and joint regression analyses.

4. CONCLUSION

In conclusion, the present set of sesame varieties showed less response to environmental changes. Thus, the influence of environment was less prominent in the manifestation of oil content along the areas of Awash valley. Moreover, the study indicated a high performance of genotypes for oil content recorded in season two (2011/12). Hence, the second season was generally identified as the best environments for oil content of sesame across the areas of Awash valley. When the six environments were compared separately, Wr.1 emerged as less interactive. Thus, this environment was identified as the best for growing the present set of varieties for breeding program. Overall results of the different stability models revealed that variety Adi was the only genotype that showed relatively little G x E interaction with reasonable mean and hence is the most stable across all environments for oil content. Therefore, this variety can be recommended as a promising cultivar for oil content across varied environments of the Afar rift valley to exploit its yield potential. The high yielding varieties *viz*., Serkamo, Tate and Argene were highly interactive and they could be recommended for cultivation under favourable environmental conditions for oil content. In this study, AMMI analysis with two IPCA was the best predictive model to reveal the maximum GEI for oil content in sesame.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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