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Performance of Sesame Variety in moisture-deficit areas of Wollo, Ethiopia

Mekonnen Misganaw and Arega Gashaw

Sirinka Agricultural Research Center, North Wollo, Ethiopia

ABSTRACT

The field experiments was conducted at Kobo, Mersa and Chefa testing sites of Sirinka Agricultural Research Center in1999 and 2000 seasons for varieties adaptation and 2004 and 2005 seasons for genotypes selection. The experiments were conducted in randomized block design using three replications with the objectives of selecting adaptable variety for the lowland areas of Wollo. Analysis of variance for each environment revealed significant differences across the tested environments and from adaptation experiment variety Abasina is high seed-yielder (12.33 qt ha-1) and had low deviation from linear regression coefficient implying its stability for different environments. Therefore, Abasina was recommended for the lowland areas of northeastern Ethiopia and from genotype selection, Pungun yonggae showed stable performance and gave high seed and oil yield across the tested environments providing a seed and oil yield advantages of 99.0% and 94.9%, respectively over the standard check, while Kelafo 74 x C-22 sel 4 had specific adaptation to more favorable environments with a seed and oil yield advantages of 106.3 and 116.7%, respectively over the standard check. Therefore, based on their performances, Pungun yonggae and Kelafo 74 x C-22 sel 4 were officially released for production with the name of Borkena, and Ahadu respectively.

Keywords: Ahadu, Borkena, Kelafo, Pungun

***Correspondence to Author:**
Mekonnen Misganaw
Sirinka Agricultural Research Center, North Wollo, Ethiopia.
E-mail: mmdagmawi@ gmail.com

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Introduction

Sesame (*Sesamum indicum* L) belongs to the genus *Sesamum*, order Tubiflorae and family pedaliaceae and is a diploid species with 2n = 2x = 26 chromosomes. Sesame's seed chemical compositions are: oil (45-55%), protein (18-25%), vitamins E, A and B complex, carbohydrate, ash and minerals like calcium, phosphorus, iron, copper, magnesium, zinc, and potassium (Ceccarelli, *et al*., 2009). From the composition of sesame oil, oleic and linoleic fatty acids are 85% and they make the oil to have long shelf-life because these fatty acids have high degree of resistance against oxidative rancidity and the linoleic acid is known to lower cholesterol content in human blood (Khanna, 1991).

The oil can be used cooking and salad oils and margarine, manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides. Sesame meal, left after the oil is pressed from the seed is an excellent high protein (34 to 50%) and used as feed for poultry and livestock.

Sesame world production is estimated at 3.24 million metric tons in 2007 and increased to 3.84 million metric tons in 2010 and almost 90% of production area was in Asia and Africa. Ethiopia was the 7th major sesame producing country in the world in the year 2004 with area coverage 65,000 hectare, production about 49,000 tons and productivity about 479 kg ha^{-1} (IPMS-Ethiopia Farmers Project, 2005). Now, Ethiopia is the 4th with area coverage 384,682.79 hectare, production about 327,740.92 tons and productivity is estimated as 852 kg ha^{-1} (CSA, 2011/12).

Next to coffee, sesame seed is the second largest export crop for Ethiopia and it is an important cash crop as it has an excellent demand in the international market and is utilized by domestic oil production. The export of sesame seeds was 43,131 tons in the year 2007 and it was almost doubled 82,201 tons in the year 2011 (CSA, 2011/12).

In the Amhara region, 207,103.06 hectares of land was covered by sesame in the year 2011, production is 157,751.9 tons, productivity 762 kg ha^{-1} and it accounts (53.84 %) area coverage, (48.13%) production in Ethiopia. In north and south Wollo zones, sesame is grown mostly inter-copping with sorghum, but these environments are potential for sesame growing as sole crops.

Despite its superior economic importance and has great potential in improving farmers' income, sesame is grown almost exclusively by smallholders using unimproved sesame landraces and traditional management practices and its production and productivity in the lowland areas of Wollo still remains below the national average (4.75 qt ha^{-1}).

So the experiments were done in 1999 and 2000 seasons as varieties adaptation, and in 2004 and 2005 seasons as genotypes selection with the idea of improving farmers' income through introducing improved varieties and selecting the best performing sesame genotypes having high seed and oil yield with the overall objective of improving sesame production and productivity in the lowlands of northeastern Ethiopia.

Materials and methods for variety adaptation

Description of the study areas

The study was conducted in the lowland areas of northeastern Ethiopia, viz., Kobo, Mersa and Chefa testing sites of Sirinka Agricultural Research Center, north Wollo, Ethiopia on well-drained soils during the 1999 and 2000 seasons. The testing sites; Kobo is located at 12^0 09' N with Eutric Fluvisol soil type,

Mersa is located at 39^0 38' E, 11^0 42' N and 39^0 36' E, but has no soil specification and Chefa is located at 10^0 57' N and 39^0 47' E with Vertisol soil type. The mean elevation of each site is 1470, 1580 and 1450 meter above sea level, respectively. Rainfall in these areas is usually unpredictable and erratic. In all seasons, most of the rainfall was recorded from July to October with terminal moisture deficit occurring in November. At Mersa, metrological station is not available, therefore, data from the nearest metrological station (Sirinka, 18 km away from Mersa) is used. The amount of rainfall during the growing seasons is presented in Table 1.

Experimental design and procedures

The experiment was conducted in a completely randomized block design with three replications. Nine nationally released sesame varieties along

Table 1 Monthly rainfall (mm) during the growing seasons at Sirinka, Kobo and Chefa in 1999 and 2000 cropping seasons.

Month	Sirinka**		Kobo		Chefa	
	1999	2000	1999	2000	1999	2000
June	16 (2)*	35 (4)	2(1)	0	NA	12
July	375 (25)	246 (18)	221(24)	224 (18)	NA	352
August	415 (23)	342 (22)	316 (21)	250 (19)	NA	365
September	85 (14)	85 (10)	105(14)	47(10)	NA	100
October	164 (16)	93 (7)	57(6)	96(12)	NA	71
November	15 (1)	50 (5)	0	24(2)	NA	33
December	0	116 (6)	0	83(4)	NA	29
Total	1212 (96)	1098 (95)	814(78)	844 (76)	NA	1096

* = Numbers in parenthesis indicate number of rainy days

Table 2 Year of release and potential oil content of nine nationally released sesame varieties

Genotypes	Year of release	Oil content (%)
T-85	1976	44
Kelafo-74	1976	43
Var-E	1978	43
Var-S	1978	43
Mehado 80	1989	44
Abasina	1990	43
Argene	1992	48
Adi	1993	46
Sercamo	1993	50
Local	-	NA

NA= Not Available

Table 3: Monthly rainfall (mm) during the growing season of sesame at six environments

	Environments					
Month	A	B	C	D	E	F
June	25.9	26.2	8.9	2.8	26.7	25.0
July	97.3	167.4	174.7	125.2	284.7	257.0
August	164.3	214.8	256.8	190.9	283.9	239.9
September	9.2	66.7	89.4	20.1	55.6	43.7
October	69.9	57.7	59.3	8.7	36.3	5.7

with one local check were evaluated for their adaptability in the lowland areas of northeastern Ethiopia. Year of release and potential oil content of the varieties are presented in Table 2.

Varieties were hand drilled in rows spaced at 40 cm and thinned to an interplant spacing of 10 cm. A gross plot size of 8 m^2 (5 m long by 1.6 m wide, 4 rows) was used. All the cultural practices were applied as per the recommendations.

Agronomic parameters such as days to 50% flowering (DF), days to 50% maturity (DM), number of pods $plant^{-1}$ (PP), number of seeds pod^{-1} (SP), plant height (PH) and seed yield (SY) were recorded. Seed yield was determined from two central rows (a net plot size of 4 m^2) after discarding border rows. Analysis of variance (ANOVA) for each location and pooled data (location x year x genotype) was performed using MSTAT-C statistical program (Michigan State University, 1988). Pooled data analysis was performed after testing the homogeneity of error variances using Bartlett's test (Gomez and Gomez, 1984).

Association of characters

Genotypic and phenotypic correlation coefficients were estimated using the standard procedure suggested by Miller *et al.* (1958) from the corresponding variance and covariance components using the following formula. Phenotypic correlation (r_p) = $\frac{\mathrm{cov}_{pxy}}{\sigma_p \, \sigma_p}$ and

Genotypic correlation (r_g) = $\frac{\mathrm{cov}_{gxy}}{\sigma_g \, \sigma_g}$

Where, Cov_{pxy} and Cov_{gxy} are phenotypic and genotypic co-variances of character x and y, respectively,

σ_p and σ_p are phenotypic standard deviations for character x and y, respectively,

σ_g and σ_g are genotypic standard deviations for character x and y, respectively.

Stability analysis

Stability analysis for genotypes across environments was computed using Statistical Package for Agricultural Research (SPAR-1) as per the stability model proposed by Eberhart and Russell (1966): $y_{ij} = \mu_i + \beta_i I_j + \delta_j$ Where,

y_{ij} is the mean performance of the i^{th} variety (i=1,2,---V) in j^{th} environment (j=1,2,---e),

μ_i is the mean of i^{th} variety overall the environments

β_i is the regression coefficient which measures the response of i^{th} variety to varying environments

δ_j^2 is the deviation from regression of i^{th} variety at the j^{th} environment and

I_j = the environmental index which is defined as the deviation of the mean of all the varieties at a given location from the overall mean, i.e. Ij = $\frac{\sum Y_{ij}}{g} - \frac{\sum\sum Y_{ij}}{g}$

According to Eberhart and Russell (1966) stability model, a variety is said to be stable if it fulfills the following requirements: (i) high mean seed yield, (ii) linear regression coefficient nearly unity and (iii) low deviation from regression, which is nearly zero.

Materials and methods for genotypes selection

Description of the study areas

The study was conducted in the lowland and moisture-deficit areas of northeastern Ethiopia, Viz., Kobo, Mersa and Chefa testing sites of Sirinka Agricultural Research Center (SARC) on well-drained soils during the 2004 and 2005 seasons. Rainfall is usually unpredictable and erratic where mostly the maximum rainfall was recorded in July and August with terminal moisture-deficit from September onwards. The amount of rainfall during the growing seasons was presented in table 3.

Experimental design and procedures

Twelve sesame genotypes along with standard and local checks were evaluated using completely randomized block design replicated three

Table 4 ANOVA for sesame seed yield and yield related characters at Mersa, Kobo and Chefa co bined over years (1999 and 2000 cropping seasons)

Source of variation	Degree of freedom	Mean squares					
		DF	DM	PP	SP	PH	SY
Mersa							
Years (Y)	1	248.07**	749.07*	1118.02ns	213.25*	681.4ns	169.23*
Varieties (V)	9	293.55**	411.30**	630.45**	375.65**	1077.11**	14.99**
Y x V	9	17.07ns	41.07**	480.07*	93.27**	242.74*	4.24ns
Error	36	8.63	10.44	166.77	67.13	99.32	4.27
CV (%)		5.29	2.84	23.36	4.23	11.50	14.72
Kobo							
Years (Y)	1	132.02*	459.27**	1372.82ns	268.35*	2381.40**	0.24 ns
Varieties	9	118.19**	337.63**	289.50ns	327.37**	1865.59**	24.44**
Y x V	9	28.54ns	56.97**	142.08ns	48.24**	47.92 ns	18.63**
Error	36	17.53	12.50	160.94	28.54	81.47	5.88
CV (%)		7.42	3.05	23.07	6.47	8.22	12.72
Chefa							
Years (Y)	1	67.18 ns	380.72*	24433.54**	42.13 ns	6203.29 ns	20.25 ns
Varieties (V)	9	145.88**	777.15**	1798.58**	223.57**	1627.98 ns	19.93**
Y x V	9	44.50**	232.78*	863.22*	78.43 ns	68.05 ns	5.53 ns
Error	36	12.82	79.10	308.45	76.08	171.02	5.16
CV (%)		6.61	7.08	25.30	8.14	12.35	15.87

* and ** denote significant difference at $p<0.05$ and $p<0.01$, respectively. ns denotes non-significant difference. Where, DF= Days to 50% Flowering, DM=Days to 50% Maturity, PP=Number of Pods plant^{-1}, SP=Number of Seeds Pod^{-1}, PH= Plant Height and SY=Seed yield (Kg/ha)

Table 5 ANOVA for sesame seed yield and yield related characters pooled over years and locations

Source of variation	Degree of freedom	Mean squares					
		DF	DM	PP	SP	PH	SY
Genotype (G)	9	178.7**	494.2**	722.3**	57.61**	1523.2**	15.8**
Environment (E)	5	40.5**	451.1**	2253.1**	15.63**	1846.2**	56.4**
G x E	45	8.2**	33**	161.5**	17.01**	57.9**	2.7**
Error	108	4.04	8.12	55.04	28.63	24	1.3
CV (%)		6.29	4.18	21.48	3.88	8.42	9.27

*, ** = Significant at $p<0.05$ and $p<0.01$, respectively

Where, DF= Days to 50% Flowering, DM=Days to 50% Maturity, PP=Number of Pods plant^{-1}, SP=Number of Seeds Pod^{-1}, PH= Plant Height and SY=Seed yield (Kg/ha) times. Genotypes were hand drilled in rows spaced at 40 cm and thinned to an interplant spacing of 10 cm with a gross plot size of 10 m^2 (5 rows x 5 meter length x 40 cm row spacing). all other cultural practices were applied as per the recommendations.

Agronomic parameters on number of days from planting to 50% maturity (Dm), thousands seeds weigh (TSW) and seed yield (SY) were recorded from plot basis. Seed yield was determined from three central rows (a net plot size of 6 m^2) after discarding border rows. Oil content (Oc) and oil yield (Oy), however were computed from treatment basis. Oil content as percentage of fat in the seed was determined by a non-destructive method of Nuclear Magnetic Resonance Spectrometry (NMRs) (Madson, 1976 cited in Nugussie and Mesfin, 1994). While, oil yield was determined as the product of seed yield and oil content using the following formula:

OY = SY*OC (%) where,

OY = Oil yield (Kg ha^{-1})

OC = Oil content (%)

SY = Seed yield (Kg ha^{-1})

Statistical analysis

Analysis of Variance (ANoVA) for six environments (three locations for two consecutive cropping seasons) was performed using MSTAT-C statistical program (Michigan State University, 1988) as per Gomez and Gomez, 1984. Data for seed yield was subjected to stability analysis using Additive Main effects and multiplicative Interaction (AMMI) model using Agrobase software program (Agrobase 1999).

Results and Discussions for variety adaptation

The results of the ANOVA for each location revealed highly significant ($p<0.01$) difference among sesame varieties for all the parameters measured except for the number of pods $plant^{-1}$ at Kobo and plant height at Chefa (Table 4). Similarly, the results of the ANOVA for the pooled data showed highly significant ($p<0.01$) differences among sesame varieties for all parameters measured (Table 5) indicating presence of adequate variability among the varieties. Furthermore, highly significant ($p<0.01$) differences were observed between environments and genotype (GxE) interactions for days to flowering and maturity, number of pods $plant^{-1}$, number of seeds pod^{-1}, plant height and seed yield (Table 4). This indicates that the phenotypic expression of these characters is highly affected by the environment due to the masking effect on the genotypes. Similarly, the phenotypic response of sesame varieties to buffer the masking effect of environments was not the same and thus varieties performed differently at different environments.

Correlation studies furnish information on the nature and degree of associations *inter se* and with seed yield. Such studies are useful in disclosing the magnitude and direction of relationships between the different characters and seed yield as well as among the characters (Sharma and Ahmad, 1978). Phenotypic and genotypic correlations between characters are presented in Table 6. At phenotypic level, seed yield had weak positive association with days to flowering (r_p= 0.170), days to maturity (r_p=0.251) and number of pods $plant^{-1}$ (0.332). At genotypic level, however, seed yield exhibited strong positive correlation with days to flowering (r_g=0.703), days to maturity (r_g=0.856), number of pods $plant^{-1}$ (r_g=0.922), number of seeds pod^{-1} (r_g=0.974) and plant height (r_g=0.878) suggesting that the genes which tend to enhance these characters also enhance seed yield. Compared to phenotypic correlation coefficients, high genotypic correlation coefficients were observed for each corresponding characters implying inherent associations of characters. Therefore, from the present correlation study it could be concluded that giving emphasis to number of pods $plant^{-1}$, number of seeds pod^{-1} and plant height is a paramount importance in improving seed yield of sesame through indirect selection in low moisture stressed areas of northeastern Ethiopia.

Mean seed yield of varieties showed significant variability ranging from 7.2 to 12.3 qt $ha^{-1}$with grand mean seed yield of 9.1 qt ha^{-1} (Table 7). The highest mean seed yield was obtained from variety Abasina (12.3) followed by Mehado-80 (10.1), while the lowest mean seed yield was obtained from Var-E (7.2). Similarly, sufficient variability was exhibited among varieties in days to maturity, which is ranging from 108 to 135 days

Table 6. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients of sesame seed yield and some yield related character

Characters	DF	DM	PP	SP	PH	SY
DF		0.986**	0.674*	0.863**	0.832**	0.703*
DM	0.637*		0.737*	0.764*	0.925**	0.856**
PP	0.332^{ns}	0.259^{ns}		0.446^{ns}	0.922**	0.922**
SP	0.437^{ns}	0.542*	0.523*		0.538*	0.974**
PH	0.438^{ns}	0.582*	0.641*	0.562*		0.878**
SY	0.170^{ns}	0.251^{ns}	0.332^{ns}	0.734*	0.584*	

*, ** = Significant at p<0.05 and p<0.01, respectively

Where, DF= Days to 50% Flowering, DM=Days to 50% Maturity, PP=Number of Pods plant^{-1}, SP=Number of Seeds Pod^{-1}, PH= Plant Height and SY=Seed yield (Kg/ha)

Table 7 Mean values of characters of sesame varieties and seed yield stability parameters

Varieties	DF (days)	DM (days)	PP (no.)	SP (no.)	PH (Cm)	SY (qtha^{-1})	Stability parameters	
T-85	50	110	54.2	39.3	94.3	7.8	1.01	-0.30
Kelafo-74	56	113	51.5	47.9	89.8	9.0	0.89	0.18
Var-E	54	115	46.1	49.1	88.9	7.2	0.86	-0.04
Var-S	55	118	54.1	48.5	89.4	8.3	1.15	-0.78
Mehado-80	58	120	56.4	45.9	100.3	10.1	1.18	-0.87
Abasina	63	132	83.1	51.5	137.8	12.3	0.90	0.34
Argene	56	120	60.2	51.8	100.9	9.9	1.30	0.59
Adi	50	108	56.1	46.0	92.2	7.4	0.83	2.04
Sercamo	49	111	64.4	43.9	94.2	9.8	0.70	7.81
Local	65	135	73.0	54.5	119.9	9.4	1.19	6.12
Mean	55	118	59.94	47.83	100.8	9.1		
LSD (1%)	1.38	2.02	4.88	3.88	3.64			

Where, DF= Days to 50% Flowering, DM=Days to 50% Maturity, PP=Number of Pods plant^{-1}, SP=Number of Seeds Pod^{-1}, PH= Plant Height and SY=Seed yield (Kg/ha) (varieties Adi and the local check, resoectively) where varieties Adi (108 days), T-85 (110 days) and Sercamo (111 days) were early maturing while the local check(135 days) and Abasina (132 days) were late maturing (Table 7). Abasina and the local check exhibited the highest number of pods plant^{-1} and number of seeds pod^{-1}. The lowest number of pods plant^{-1} in Var-E and number of seeds pod^{-1} in T-85, were recorded (Table 7).

Stability analysis for seed yield showed that T-85, Abasina and Kelafo-74 had linear regression coefficient () not significantly different from unity (ranging from 0.89 to 1.01) indicating that good response to both favorable and unfavorable environments (Table 7). In contrast, variety Sercamo had the lowest regression coefficient, which is significantly different from unity, indicating better response to unfavorable environments whereas variety Argene had the highest regression coefficient (1.30), which is significantly different from unity implying better response in favorable environments. On the other hand, deviation from linear regression () for variety Abasina, T-85, Var-E and Kelafo-74 are low, which is not significantly different from zero (ranged from –0.30 to 0.34) indicating stable performance over variable environments. Varieties T-85, Var-E and Kelafo-74 are poor yielder although they had stable performance over variable environments as expressed by their low deviation from linear regression (). Whereas, variety Abasina gave the highest and stable seed yield over diverse environments (Table 7) thus recommended for production in the northeastern quadrant of Ethiopia.

Environments (locations and years) were stratified based on environmental indices (Table 8). Environmental index ranged from –3.75 to 2.48 where the highest negative environmental index was exhibited by environment-four (Mersa-2000) followed by environment-one (Chefa-1999) showing that these environments were the most unfavorable environments for sesame production. This could be confirmed by the lowest environmental mean seed yield (5.3 and 7.8 qt ha^{-1}, respectively). Environment-five (Kobo-1999) and environment-six (Kobo-2000), on the other hand, had the highest positive environmental indices implying that these environments are the most favorable environments for sesame production. This can be further justified by the highest environmental mean seed yield (11.6 and 11.5 qt ha^{-1}, in that order). Therefore, based on environmental index analysis, Kobo is found a good environment for sesame production.

Results and Discussions for genotype selection

I. Days to maturity

In environments where rainfall is insufficient in amount and erratic in distribution, selection of early maturing genotypes that could escape terminal moisture-stress is the primary and best option to maximize production and productivity of crops. With regard to this trait, genotypes showed highly significant variations (Table 9) where most of the genotypes took short maturity periods except for local and standard checks (Table 10).

II. Seed yield

Genotypes showed highly significant differences for seed yield in all the six environments (Table 9) implying the presence of sufficient genetic variability among the genotypes. Genotype-environment (GxE) interaction showed highly significant variation implying the ranking of genotypes across environments are not consistent. Therefore, identifying genotypes that showed specific adaptation or that possessed greatest seed yield stability is an important consideration. In all the environments, Kelafo 74 x C-22 sel 4 (1134.8), Acc-111-804 (1130.8) and Pungun yonggae (1095.0) gave maximum seed yield (Table10) providing a seed yield advantage of 106.3%, 105.5% and 99.0%, respectively over the standard check (Abasena) (Table 10) denoting these genotypes are genetically high yielder. Environment-wise, highest seed yield was obtained in environment-C (Chefa 2004) followed by environment-E (Mersa 2005) and environment-F (Chefa 2005) where amount and distribution of rainfall for these environments were relatively better (Table 11).

III. Oil content and oil yield

Based on Nuclear Magnetic Resonance spectrometry analysis, Acc-111-804 had the highest oil content followed by Bcs-043 and Gobiye-82 (Table 10). Oil content is a quantitative trait which is significantly affected by variable environments. Thus highest oil content was obtained

Table 8 Mean seed yield ($qtha^{-1}$) of sesame varieties tested in six environments pooled over three replications

Genotypes	Environments					
	E_1	E_2	E_3	E_4	E_5	E_6
T-85	6.8	7.7	8.2	3.1	10.7	8.8
Kelafo-74	8.0	9.1	8.3	5.7	9.6	12.9
Var-E	4.6	7.9	7.1	4.2	8.2	10.2
Var-S	5.6	8.7	7.8	4.2	11.1	10.9
Mehado-80	9.9	10.4	9.1	5.2	12.8	13.0
Abasina	9.5	11.7	12.1	9.8	14.1	15.6
Argene	8.5	11.5	10.7	4.2	13.1	11.4
Adi	6.1	6.5	7.8	4.4	12.0	7.3
Sercamo	12.1	8.5	8.6	6.4	14.1	10.1
Local check	7.3	12.2	6.7	6.2	10.0	15.0
Env. Mean	7.8	9.4	8.6	5.3	11.6	11.5
Env. Index	-1.05	0.33	-0.45	-3.75	2.48	2.43

E_1= Chefa 1999, E_2= Chefa 2000, E_3=Mersa 1999, E_4=Mersa 2000, E_5=Kobo 1999 and E_6=Kobo 2000

Table 9: Analysis of Variance (ANOVA) for days to maturity (DM), thousand seeds weight (TSW) and seed yield (SY)

Source of variations	Degree of freedom	Mean squares DM	TSW	SY
Replications (R)	2	6.39**	0.3	218166
Genotypes (G)	11	1200.7**	1.4**	1130173**
Environments (E)	5	15879.9**	0.5**	1824051**
GxE	55	93.5	0.2	**
IPCA1	15			**
IPCA2	13			**
CV	13	3.3	13.9	35.1
LSD at 5%	Genotypes	2.6	0.3	247.1
	Environments	1.8	0.2	174.7
	GxE	6.3	Ns	Ns

Contribution of IPCA1 and IPCA2 was 56.9% and 28.7, respectively from Chefa and Mersa. Similarly, oil yield is the basic economic trait for sesame production. Highest oil yield was obtained from Acc-111-804 (576.7 kg ha^{-1}) followed by Kelafo 74 x C-22 sel 4 (566.3 Kg ha^{-1}) and Pungun yonggae (509.2 Kg ha^{-1}) providing oil yield advantage of 120.7%, 116.7% and 94.9%, respectively over the standard check (Table 10).

IV. Seed size

In addition to seed and oil yield, seed size is another important genetic trait for sesame production, mainly for export purpose. Thousand seed weight of more than three gram is regarded as the minimum premium seed size standards for export (Personal communication). Therefore, based on seed size genotypes exhibited significant variations (Table 9) where Pungun yonggae consistently had the highest seed size which could qualify export standards (Table 10).

V. Stability analysis

AMMI showed only the first two Interaction Principal Component Analysis (ICPA) axes were found significant where the majority (56%) of the genotype-environment interaction was explained by IPCA1 (Table 12). Based on mean seed yield and IPCA1 axis scores, genotypes and environments are plotted in a biplot graph (Fig. 1). Biplot sensibly sorted out the performance of genotypes across environments. Genotypes and environments which are located at the left side of the ordinate yielded below average seed yield while those located at the right hand side of the ordinate yielded above the grand mean. Therefore, Kelafo 74 x C-22 sel 4, Acc-111-804, Nn-008 and Pungun yonggae gave above average seed yield (Fig. 1).

Similarly, genotypes and environments are plotted near or away from the x-axis. Acc-111-804, Pungun yonggae and Nn-008 had IPCA1 values of nearly zero (-3.2, -1.8 and -3.5, respectively) (Table 12). Thus these genotypes are plotted near the abscissa (Fig. 1.) implying small interaction effects to variable environments and hence could be explained by additive main effect. Therefore, Acc-111-804, Pungun yonggae and Nn-008 had wide adaptation areas. On the other hand, Kelafo 74 x C-22 sel 4 had highest IPCA1 values (-18.1) thus plotted away from the abscissa indicating the performance of the genotype for seed yield is significantly affected by variable environments. Kelafo 74 x C-22 sel 4 is plotted at the fourth quadrant along with high potential environment (Chefa) which receives the same sign of IPCA score (Fig.1.). On the other hand, distance from the origin of the biplot to the environment is an indication of the measure of discriminating abilities. Environments had large IPCA values, except environment-B (Mersa 2004) indicating high discrimination potential (Table 12).

Conclusions and recommendations

From the adaptation trial, it could be concluded that variety Abasina is out-smarted in seed yield and thus recommended to low moisture-defict environments of northeastern Ethiopia, Wollo. Therefore, to boost up the production and productivity of sesame, demonstration and popularization of variety Abasina should be done in large extent.

From genotypes selection, based on seed and oil yielding potential, Pungun yonggae was found superior and stable genotype for moisture-defict areas of Wollo and Kelafo 74 x C-22 sel 4 is a cross between Kelafo 74 (an indigenous sesame collection from Kelafo) with exotic sesame genotype C-22 selection 4 showed highest seed and oil yields having specific adaptation to relatively high potential environments. Therefore, the National Variety Releasing Committee (NVRC) approved the release of these two genotypes; Pungun yonggae for Kobo, Mersa, chefa and other similar environments and named *Borkena* indicating its best performance at *Borkena* watershed, and Kelafo 74 x C-22 sel 4 for Chefa and other similar environments and named *Ahadu* (referring the first sesame variety released to Chefa areas).

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References

Table 10: mean seed yield and other agronomic traits of 12 sesame genotypes tested at six environments (Kobo, Mersa and Chefa during 2004 and 2005 cropping seasons).

Genotypes	DM	TSW	SY	Mean oil content (%)	Mean oil yield (Kg ha^{-1})	Seed yield advantage over standard check	Oil yield advantage over standard check
Co-1	117	2.8	809.3	49.4	399.8	47.1	53.0
Nn-008	114	2.1	963.2	49.3	474.9	75.1	81.7
Acc-111-804	112	2.9	1130.8	51.0	576.7	105.5	120.7
Bcs-043	113	2.6	668.8	50.5	337.7	21.6	29.3
Kelafo 74 x C-22 sel 4	114	2.7	1134.8	49.9	566.3	106.3	116.7
Acc-215 816	112	2.6	740.5	49.8	368.8	34.6	41.1
Gobiye-82	114	2.8	795.2	50.2	399.2	44.5	52.8
Nn-0025	111	2.8	795.3	48.2	383.3	44.5	46.7
Pungun yonggae	116	3.1	1095.0	46.5	509.2	99.0	94.9
Giza 32	115	2.7	786.2	49.6	390.0	42.9	49.2
Abasena	136	2.8	550.2	47.5	261.3	-	-
Local check	133	2.7	433.8	49.5	214.7	-21.2	-17.8
Environmental means	117	2.7	825.3	49.3	406.9	-	-

Table 11: performance of sesame genotypes for seed yield across six environments

Genotypes	**Environments**						**Genotypic mean**
	A	**B**	**C**	**D**	**E**	**F**	
Co-1	840.9	716.6	1016.7	645.1	991.2	645.5	809.3
Nn-008	665.4	866.2	1422.9	776.5	1040.8	1007.2	963.2
Acc-111-804	840.6	1033.9	1584.8	944.7	1210.8	1170.1	1130.8
Bcs-043	487.5	573.3	1039.4	490.1	783.3	639.4	668.8
Kelafo 74 x C-22 sel 4	496.4	1033.4	1855.7	925.1	1104.6	1393.9	1134.8
Acc-215 816	514.4	644.4	1145.4	558.7	840.8	739.3	740.5
Gobiye-82	166.0	693.9	1508.9	586.1	767.9	1048.3	795.2
Nn-0025	698.5	700.9	1101.1	622.4	936.5	712.5	795.3
Pungun yonggae	837.0	998.5	1524.3	911.1	1185.2	1113.9	1095.0
Giza 32	677.8	691.6	1100.8	612.4	923.7	710.7	786.2
Abasena	711.4	459.1	658.2	394.7	773.1	304.5	550.2
Local check	385.1	340.1	702.8	264.1	590.3	320.7	433.8
Environmental means	**610.0**	**729.3**	**1221.8**	**644.3**	**929.0**	**817.2**	**825.3**

Table 12: Designations, IPCA1 scores and means seed yield of 12 sesame genotypes and six environments

Designations	Genotypes and environments	IPCA scores	Mean seed yield (Kg ha^{-1})
Genotypes			
a	Co-1	10.6	809.3
b	Nn-008	-3.5	963.2
c	Acc-111-804	-3.2	1130.8
d	Bcs-043	1.4	668.8
e	Kelafo 74 x C-22 sel 4	-18.1	1134.8
f	Acc-215 816	-0.5	740.5
g	Gobiye-82	-17.7	795.2
h	Nn-0025	5.1	795.3
i	Pungun yonggae	-1.8	1095.0
j	Giza 32	4.6	786.2
k	Abasena	16.1	550.2
l	Local check	7.1	433.8
Environments			
A	Kobo-2004	23.4	610.1
B	Mersa-2004	0.3	729.3
C	Chefa-2004	-17.9	1221.8
D	Kobo-2005	1.6	644.3
E	Mersa-2005	7.4	929.0
F	Chefa-2005	-14.7	817.2

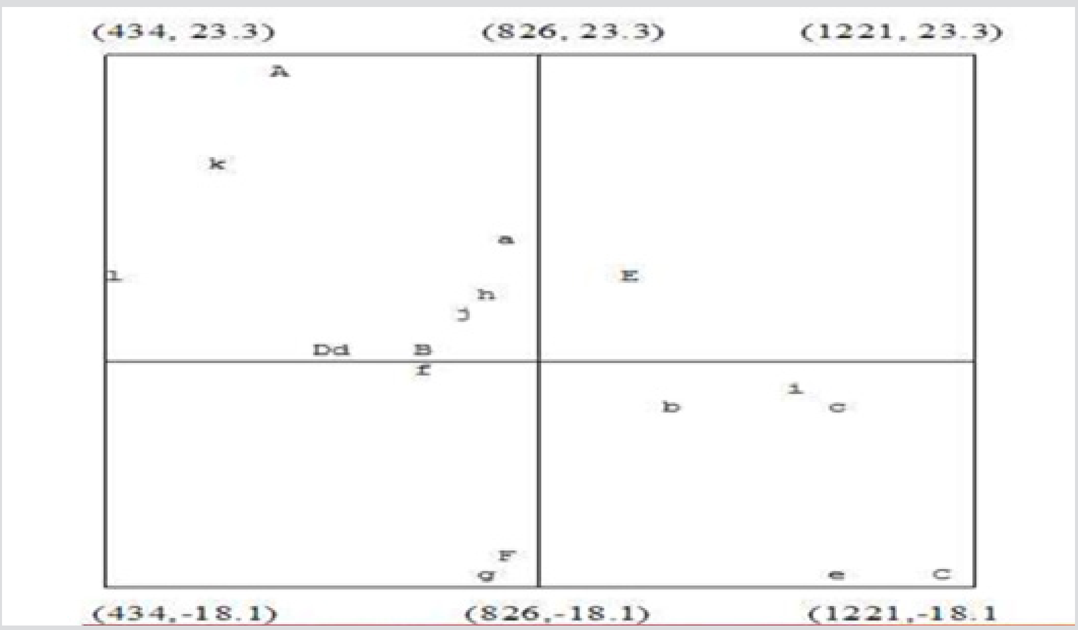

Fig.1. Biplot with abscissa (X-axis) plotting means from 434 to 1221 and with ordinate (Y- axis) plotting IPCA1 from -18.1 to 23.3. Genotypes plotted as a,b,c, ... and environments as A,B,C, ...,

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