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Original Research Article

Genetic Variability, Heritability and Genetic Advance of Ten Sesame (*Sesamum indicum* L.) varieties at Omo Kuraz, Southern Ethiopia

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Abstract: Ten sesame varieties were evaluated using Randomized complete block design with three replications at Omo kuraz -1 sugar development project of South Omo, Southern Ethiopia, during 2018/19 under irrigated condition to estimate phenotypic and genotypic coefficients of variation, heritability and genetic advance for some important characters in sesame (*Sesamum indicum* L.). The treatment consisted of ten varieties of sesame namely: E, Tate, Kelafo-74, Mehando-80, T-85, Adi, Abasena, S, Argene and Serkamo. Data were collected on phenological, growth, yield, yield components, oil content and oil yield and analyzed using SAS software version 9.0. The results showed that there were significant differences among the varieties for all characters studied. High estimates for GCV and PCV were observed in seed yield and oil yield, While Plant height to first branch, Plant height to first capsule, number of capsules per plant and harvest index showed moderate PCV and GCV and the remaining traits recorded low PCV and GCV. High estimates for heritability values were observed for traits Seed yield, Plant height to first branch, TSW, Plant height to first capsule, internode length and harvest index which indicated that for breeding activities and can be utilized in subsequent selections based on phenotypic expressions of individual plants for specific traits. And it further indicates the limited influence of the environment on the phenotypic expressions of the traits. Further computation for GAM indicated that high estimates were found for Seed yield, number of capsules per plant, Harvest index, Plant height to first branch, Plant height to first capsule which could further confirm the easy of selections based on phenotypic traits after cycle of selection using 5 % selection intensity. This study generally indicated that there were significance genetic variations among the varieties. Thus, there is enormous opportunity of using the germplasm in the improvement program for employing different breeding techniques for selection of varieties for significant increment in economic traits like seed yield, percent oil content and oil yield.

Keywords: Sesame, co-efficient of variation, heritability and Genetic Advance.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.*)* belonging to family Pedaliaceae is one of the oldest cultivated oil-rich plants in the world (Yasin and Genene, 2017) which is widely known for its excellent nutritional, medicinal, cosmetic and cooking qualities of its oil (Duhoon *et al.* 2000). It contains high amount of oil hence sesame is known as the king of oil seeds (Sharma *et al.*, 2014). Ethiopia is among the major sesame producing countries in the world.

Despite, its superior national economic importance and great potential in improving farmers' income, the crop is almost exclusively produced by smallholders using limited number of variety with productivity below the national average yield (4.75 qt/ha) in the lowland areas of South Omo zone (Tadese and Misgana, 2017). The poor productivity might be associated genetic potential of varieties and nature of growing environment (Zenebe, 2010).

Besides, knowledge of the naturally occurring diversity in a population helps to identify diverse groups of populations that can be useful for the breeding program. Sesame breeding programs started before three decades in Ethiopia and so far 18 varieties were released for different agro-ecologies in the country based on the moisture, temperature and soil

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requirements , however only three varieties were produced for export purpose (Wijinands *et al*., 2007; Geremew *et al*., 2012;) while the others are out of production due to different reasons.

Genetic diversity studies were done by different researchers for Ethiopian sesame collections in different times (Endale and Parzies, 2011; Alemu *et al*., 2013, Desawi *et al*., 2014, Hika *et al*., 2014) and the researchers reported that phenotypical and genetic variations have been detected in the specific populations studied. Endale and Parzies (2011) studied 50 populations of Ethiopian sesame using SSR markers and ample amount of genetic variations were reported. Alemu *et al*. (2013) reported that significant genetic variation were detected using ISSR markers among six farmers' varieties of sesame from Northern Ethiopia indicating that Ethiopia has ample genetic resources of sesame which could be utilized for improvement programs. Knowledge on the extent and pattern of genetic variability present in a specific breeding population is absolutely essential for further improvement of the crop.

The logical way to start any breeding programme is to assess the existing genetic variability, because, the assessment of variability forms the basis of any crop improvement program. It is necessary to study variability in respect of quantitative characters with reference to genetic parameters such as genotypic and, phenotypic variances, heritability (broad sense) and genetic advance. Boureima *et al*. (2016) reported that genetic and breeding improvement efforts in the sesame have been limited, making the results of such efforts slow to emerge. Effective selection criteria and additional genetic information for breeders are insufficient. So would be used effectiveness selection methods in which associated criteria with the sesame yield. Wide information on phenotypic and genotypic variability would be available for a plant breeder. Hika *et al*. (2015) stated that using the germplasm in the improvement program is considered a great opportunity for the genotype selection of high yielding productivity. The higher PCV rather than the GCV indicates that trait expression is highly affected by environmental effects. Broad sense heritability refers to the percentage of genetic sharing for the trait expressions.

The broad sense heritability estimated alone is not reliable, because these estimations values are might be affected by the environmental and plant material changes. Using high broad sense heritability (H_b) coupled with higher genetic advance (GA) is more preferred and helpful in prediction gain under selection due to the additive gene action, reported by El Soury *et al*. (2016) and Patil & Lokesha (2018). Therefore, the present study was carried out to know the nature and extent of genetic variability, heritability and genetic advance in some important traits of ten sesame varieties.

2. MATERIALS AND METHODS

2.1. Description of Experimental Site

The study was conducted at Omo Kuraz sugar project during cropping season of 2018 under irrigated conditions. The area is located between latitudes and altitudes ranging from 5o 8’ 18” to 6o 16’ 59” and 35o 43’ 37” to 36o 13’ 54”, respectively, in Southern part of Ethiopia about 918 kms of Addis Ababa with elevation ranging from 370 – 500 meters above sea level (Tadesse and Ambachew, 2009). The mean minimum and maximum air temperatures are 23.5 °C and 35.7 °C, respectively.

2.2. Experimental Materials and Design

The treatments consisted of ten varieties of sesame namely: E, Tate, kefalo-74, Mehando-80, T-85, Adi, Abasena, S, Argene and Serkamo. The seeds of the tested varieties were collected from Werer Agricultural Research Center. The experiment was conducted in randomized complete block design (RCBD) with three replications. The varieties were planted at 40cm X10cm spacing with 0.60cm and 1m plot and block distances, respectively. 100kg/ha DAP and 50kg /ha Urea were applied at the time of sowing and flowering initiation, respectively.

2.3. DATA COLLECTION

Data were recorded on days to 50% seedling emergence, days to 50% flowering, days to 90% maturity, plant height to first branch (cm), plant height to first capsule (cm), internode length (cm), dry matter (kg/ha), number of capsules per plant, number of seeds per capsule, thousand seed weight (g), seed yield (kg/ha), harvest index and oil content (%). Oil content of seeds: - was determined following the NMR (nuclear magnetic resonance) method. Oil yield (kg/ha) was determined using the formula: Oil yield (kg /ha) =seed yield *oil content of seed /100).

2.4. DATA ANALYSIS

All collected data were subjected to the analysis of variance (ANOVA) using statistical procedure described by Gomez and Gomez (1984) with the help of SAS software version 9.0 (SAS, 2004). Means were compared using least significance difference (LSD) at 5% level of significance.

In addition, the parameters for the phenotypic and genotypic variability were calculated according to Burton (1952) and Al-Jibouri *et al*. (1958) as follow:

1. **Genotypic variance ($\sigma^2 g$) = (MSg – MSe)/r**

Environmental variance ($\sigma^2 e$) = Mse

Where, MSg and MSe are the mean sum of squares for the genotypes and error in the analysis of variance, respectively r is the number of replications.

The phenotypic variances were estimated as the sum of the genotypic and environmental Variances.

2. Phenotypic variance ($\sigma^2 ph$) = $\sigma^2 g + \sigma^2 e$

The genotypic and phenotypic coefficients of variability were calculated according to the formulae of Singh and Chaundary (1977).

3. Genotypic Coefficient of Variation (GCV) = (σg/grand mean) * 100

Phenotypic Coefficient of Variation (PCV) = (σph / grand mean) * 100

4. Heritability in broad sense (hb^2) for all characters was computed as per the following formula adopted from Allard (1960).

$hb2=\sigma^2 g/\sigma^2 ph*100$

5. Genetic Advance (GA) = k*H* σph

Where, k is the intensity of selection (k =2.06 at 5% selection intensity).

6. Genetic advance as per cent of mean (GAM)

GAM (%) = Genetic advance (GA) divided by General mean of population (Gm) × 100

3. RESULTS AND DISCUSSION

3.1. Analysis of Variance

The analysis of variance showed that all the studied characters showed significant differences (P<0.05) among the tested sesame varieties. This indicates the presence of adequate variability which can be exploited through selection for improving specific traits (Table 1).

Table-1: Mean square values for different morphological and oil yield traits of ten sesame varieties.

SN	characters	Mean square		
		Replication	Treatment	Error
1	Days to 50 % flowering	0.70	4.29^{*}	1.44
2	Days to 90 %maturity	0.70	6.05^{*}	2.51
3	Plant height to first branch (cm)	5.20	31.98^{***}	1.38
4	Plant height to first capsule (cm)	4.30	106.27^{***}	6.67
5	Internode length (cm)	3.03	4.15^{**}	0.77
6	Number of capsule per plant	4.43	181.27^{***}	13.84
7	Number of seeds per capsule	5.63	64.42^{***}	3.04
8	Thousand seed weight (g)	0.01	0.39^{***}	0.01
9	Seed yield (Kg h^{-1})	562.94	149312.07^{***}	4846.2
10	Biomass yield(Kg h^{-1})	623043	359320.58^{*}	148028.51
11	Harvest Index	0.002	0.01^{**}	0.002
12	Oil content (%)	0.75	3.15^{*}	1.09
13	Oil yield (Kg h^{-1})	102.09	36987.57^{***}	1283.5

Values indicated by *, ** and *** denotes significant differences at 0.05, 0.01 and 0.001 levels of probability, respectively.

3.2. Mean Comparison for seed yield, harvest index and oil yield

Among the tested sesame varieties, Tate gave the highest seed yield (1468.68 kg/ha) over the remaining varieties which was at statistical parity with values obtained from variety Mehando-80 (1364.61kg/ha). On the other hand, Abasena gave the lowest seed yield (740.95 kg/ha) as compared to other varieties which was at statistical parity with values obtained from Adi variety.

Analysis of variance showed highly significance difference (P < 0.01) among sesame varieties in harvest index (Table 1). From the tested varieties, Mehando-80 gave maximum harvest index (0.40) over the rest varieties with no statistical difference with values obtained from varieties Tate and Serkamo. Contrarily, Abasena gave minimum harvest index (0.22) which was not statistically different from values obtained from varieties Kelafo-74, T-85, Adi and Argene. This result agrees with the work of Dereje (2012) who reported a highly significant variation in harvest index in sesame varieties. Moreover, this variation may be related to variation in days to maturity and seed yield (kg/ha) among tested varieties which could be evidenced by significant linear relationship of these parameters with harvest index (Table 2).

Table-2: Seed yield, Harvest index, oil content and oil yield of sesame Varieties

Treatments	Seed yield(kg/ha)	Harvest index	Oil content (%)	Oil yield (kg/ha)
E	1114.74^{b}	0.31^{bc}	48.6^{ab}	541.71^{cd}
Tate	1468.68^{a}	0.39^{ab}	49.18^{a}	722.56^{a}
Kelafo -74	1232.04^{b}	0.30^{cd}	47.16^{b}	580.48^{bc}
Mehando-80	1364.61^{a}	0.40^{a}	46.90^{bc}	640.14^{b}
T-85	994.77^{c}	0.26^{cde}	46.98^{bc}	467.35^{ef}
Adi	833.54^{d}	0.23^{de}	47.16^{b}	393.10^{g}
Abasena	740.95^{d}	0.22^{e}	47.05^{bc}	348.60^{g}
Serkamo	1114.68^{b}	0.34^{abc}	47.40^{ab}	528.34^{cde}

Treatments	Seed yield(kg/ha)	Harvest index	Oil content (%)	Oil yield (kg/ha)
S	1117.96^{b}	0.31^{bc}	45.33^{c}	507.32^{def}
Argene	986.38^{c}	0.28^{cde}	47.25^{b}	466.22^{f}
Mean	1096.83	0.30	47.30	519.58
LSD	119.42	0.08	1.79	61.45
CV (%)	6.34	15.61	2.21	6.89

The result of the study had also revealed significant difference ($P < 0.05$) among sesame varieties in oil content (Table 1). The mean values for oil content of varieties ranged from 45.33% to 49.18 % where the maximum oil content (49.18 %) was recorded in Tate which was statistically at parity values obtained from E and Serkamo varieties. On the other hand, the minimum oil content (45.33 %) was observed in variety S. Similarly, oil yield (kg/ha) was also observed to highly significantly ($P < 0.001$) varied among varieties (Table 1). The highest oil was yield (722.56 kg/ha) recorded in Tate variety whereas the lowest and statistically similar values of oil yields were observed in Abasena (348.60kg/ha) and Adi (393.10kg/ha) varieties (Table 2).

3.3. COEFFICIENT OF VARIATION

The phenotypic and genotypic variability plays an important role in sesame breeding program across hybridization and selection (Begum & Dasgupta, 2014; Begum *et al.*, 2017 and Aye *et al.*, 2018). Genetic variability is one of the important considerations in any crop improvement which is needed to study in detail. Variability is measure by estimation of genotypic and phenotypic variance (σ^2g and σ^2p), genotypic and phenotypic coefficient of variation (GCV and PCV), heritability, genetic advance and genetic advance as per cent of mean. These parameters help in selection for improvement of desired characters. Environment plays an important role in the expression of phenotype. The phenotypic variability which is observable includes both genotypic (heritable) and environmental variation (non-heritable). Hence, variability can be observed through biometric parameters like GCV, heritability (broad sense) and genetic advance.

The phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all the characters studied, indicating that the environment had an important role in the expression of these characters. As stated by Shivasubramanian and Menon (1973) the PCV and GCV values are ranked as low, medium and high with 0 to 10%, 10 to 20% and >20% respectively likewise, seed yield per plant and oil yield showed high phenotypic and genotypic coefficient of variation (PCV= 21% and GCV= 20%). There is enough scope for selection based on this character, and the diverse genotypes can provide materials for a sound breeding programme. While Plant height to first branch, Plant height to first capsule, number of capsules per plant and harvest index showed moderate PCV and GCV and the remaining traits recorded low PCV and GCV. Sudhakar *et al*. (2007), and Shadakshari *et al*. (1995) reported low phenotypic and genotypic coefficient of variation for the characters days to fifty per cent flowering, days to maturity and oil content. Low co efficient of variation for number of seeds per capsule was reported by Thangavel *et al*., (2000).

Table-3: Estimates of genetic components of variance, heritability and genetic advance for different traits of ten sesame varieties

Traits	σ^2g	σ^2p	σ^2e	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)	Mean
DF	0.95	2.4	1.44	2.5	4.0	39.6	1.24	3.26	38
DM	1.18	3.69	2.51	1.31	2.33	32	1.26	1.53	82.4
PHFB	10.2	11.58	1.38	13.6	14.52	88.1	6.17	26.3	23.4
PHFC	33.2	39.8	6.67	10.6	11.62	83.4	10.78	20	54.2
IL (cm	1.15	1.92	0.77	9.55	12.3	60.0	1.67	15	11.2
NCPP	55.8	69.6	13.8	17.2	19.1	80.2	13.7	31.5	43.46
NSPC	20.5	62.32	3.04	7.2	12.8	31	5.00	8.2	62.26
TSW	0.12	0.14	0.02	9.7	10.5	85.7	0.64	18.5	3.5
SY	48155	53001.5	4846.3	20	21	90.8	427	39	1096.8
BY	70430	218458	148028	7	12.2	32.2	308.5	8.1	3831.2
HI	0.003	0.005	0.002	16.1	22.5	60	0.09	29	0.31
OC	0.68	1.78	1.1	1.73	2.8	38.2	1.04	2.2	47.3
OY	11901.1	13184	1283.5	21	22.1	90.1	213.1	41	519.5

Where, DF = Days to 50 % flowering, DM = Days to 90 %maturity, PHFB = Plant height to first branch (cm), PHFC = Plant height to first capsule (cm), IL = Internode length, , NCPP= Number Capsules per plant , NSPC =Number of seeds per capsule, TSW= thousand seed weight (g), SY = Seed yield (kg ha^{-1}), BY = Biomass Yield (kg ha^{-1}), HI = harvest index, OC= Oil content (%), OY= oil yield (kg ha^{-1}) phenotypic (σ^2p), genotypic (σ^2g) and environmental (σ^2e) components of variances, phenotypic (PCV) and genotypic (GCV) coefficients of variation, broad sense heritability (h^2), expected genetic advance (GA) and genetic advance as percent of the mean (GAM).

3.4. HERITABILITY

Heritability is a good index of the transmission of characters from parents to their offspring (Falconer, 1989). For making effective improvement in the characters for which selection is practiced, heritability has been adopted by large number of workers as a reliable indicator. The estimates of heritability help plant breeder in selection of elite genotypes from diverse genetic population. Estimates of heritability are more advantageous when expressed in terms of genetic advance. However it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*., 1955). Genotypic coefficient of variation is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. According to Singh (2001), heritability values greater than 80% are very high, values from 60 to 80% are high and values from 40 to 59% are medium and values less than 40% are low Accordingly, heritability estimates obtained were high for all the characters studied except Days to 50% flowering, Days to 90% maturity, number of seed/capsule, biomass yield and oil content which recorded very low heritability (Table 3). High value of heritability indicates that there would be a close correspondence between the genotype and the phenotype due to the relative small contribution of the environment to the phenotype. But, for characters with low heritability, say 40% or less, selection may be considerably difficult or virtually impractical due to the masking effect of the environment.

Heritability estimates along with expected genetic gain is more useful than the heritability value alone in predicting the resultant effect for selecting the best genotypes (Johnson *et al.*, 1955). Estimates of heritability and genetic advance in combination are more important for selection than heritability alone. According to Johnson *et al.* (1955), genetic advance as percent of mean (GAM) was categorized as high (>20%), moderate (10-20) and low (0-10). Accordingly, high heritability combined with high genetic advance (as per cent of mean) observed for Plant height to first branch , number of capsules per plant, seed yield per plant, harvest index and oil yield showed that these characters were controlled by additive gene effects and phenotypic selection for these characters would likely to be effective. This indicates the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance. Similar results were reported by Reddy *et al*. (2001) and Krishnaiah *et al*. (2002). Days to 50 % flowering, Days to 90 % maturity, Number Capsules per plant, Biomass Yield and oil content showed low heritability and low genetic advance which may be due to non-additive gene action.

According to Johnson *et al*. (1955), high heritability estimates along with the high genetic advance is usually more helpful in predicting gain under selection than heritability estimates alone. Emphasis should be placed on those characters which had high heritability and genetic advance for formulating reliable selection indices for the development of high yielding sesame varieties.

4. CONCLUSION

A study was conducted to determine the extent of genetic variability, heritability and genetic advance among ten sesame varieties at Omo kuraz sugar project, Ethiopia. The results for analysis of variance showed that there were significant differences among the ten varieties for all characters considered. High values for GCV and PCV were observed in the varieties for seed yield which could indicate the varieties were variable in seed yield and could be used for breeding programme. High to very high estimates for heritability values were observed for Plant height to first branch, Plant height to first capsule, Internode length, Number Capsules per plant thousand seed weight, Seed yield, harvest index and oil yield which indicated that selection based on the phenotypes for specific objectives/traits are effective. And it further indicates the limited influence of the environment on the phenotypic expressions of the traits. Further computation heritability combined with high genetic advance for GAM indicated that high estimates were found for Plant height to first branch, number of capsules per plant, seed yield, harvest index and oil yield showed that these characters were controlled by additive gene effects and phenotypic selection for these characters would likely to be effective which could further confirm the easy of selections based on phenotypes after cycle of selection using 5 % selection intensity. Thus, there is enormous opportunity of using the germplasm in the improvement program for employing different breeding techniques for selection of varieties with significant increase in economic trait.

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