Genetic Variability in Sesame (*Sesamum indicum L.*) Genotypes for Shattering and Shattering-Related Traits

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Abstract: Shattering has a substantial yield reduction in sesame. Sixty-four sesame genotypes were evaluated using 8 x 8 lattice design with two replications at the main research station of Pawe Agricultural Research Center to assess the genetic variability among sesame genotypes for shattering and shattering-related traits. Data were collected on days to first capsule opening, days to 90% maturity, number of opened-capsules plant^{-1}, number of total capsules plant^{-1}, length of cracking on opened-capsule, number of seeds dropped opened-capsule^{-1}, number of seeds dropped opened-capsule^{-1} while the capsule is inverted, and the number of seeds retained opened-capsule^{-1}. In the present study, the mean seed retention and rate of shattering capsule^{-1} ranged from 22.56% to 73.71% and from 26.20% to 77.78%, respectively. Analysis of variance revealed significance difference ($P<0.05$) among sesame genotypes for number of days from first capsule-opening up to days to 90% maturity, while the evaluated genotypes showed non-significant difference ($P>0.05$) for rate of shattering and other shattering-related traits which indicated low scope of improvement for shattering resistance through the evaluation and selection of landraces. Furthermore, low estimates of heritability and genetic advance as percentage of the mean for shattering and its related traits indicated that an environment had a significant influence on these traits, which suggests breeders to evaluate sesame genotypes for shattering resistance based on molecular data rather than phenotypic data for reliable results and valid recommendations.

Keywords: Days to First Capsule Opening, Phenotypic Coefficient of Variation, Genotypic Coefficient of Variation, Genetic Advance, Heritability

1. Introduction

Sesame is the oldest oilseed crop which is domesticated 3050–3500 B. C. [1]. Among several species of the crop, *Sesamum indicum* has been popularly grown worldwide [2]. Sesame is a self-pollinating crop which may be reproduced via cross-pollination. The crop grows well in many tropical and subtropical ecological zones across the world. Despite its tolerance to drought and high temperature [2], sesame is susceptible to salt and lodging [3]. In Ethiopia, sesame thrives across semi-arid areas of Amhara and Tigray, the lowlands of Oromia, Benishangul Gumuz, and Somali regions [4]. Currently, sesame has been extensively produced in Africa and Asia for its nutritious seeds [5]. Sesame is a cash crop for smallholder farmers and source of foreign currency for Ethiopia [6].

Despite a tremendous nutritional and economic importance of sesame, the productivity of sesame cultivars grown in Ethiopia is low due to the genetic and environmental factors. Low-yielding and poor adaptability of cultivars to harsh weather conditions, bacterial blight disease, and seed shattering are the major sesame productivity in Ethiopia. Sesame has two growth types, determinate and indeterminate [7]. Cultivars with determinate growth promote uniform capsule ripening, whereas cultivars with indeterminate growth promote continuous capsule production as long as the environment remains suitable for growth [8-9]. Capsules from the bottom of the stem become ripened and then opened ahead of the ripening of capsules at the tip of the stem and branches as result of non-uniform capsule maturity. Thus, non-uniform capsule maturity makes unsuitable condition for harvesting which finally results shattering and seed yield loss in sesame. The major goal of Ethiopian sesame breeding is to develop high-yielding varieties with shattering and bacterial blight resistance characteristics and better seed quality [9]. Crop improvement depends on the presence of genetic variability

and the information of genetic parameters of quantitative traits. In order to mitigate yield loss as result of shattering in sesame, assessing the extent of genetic variability among sesame genotypes and understanding the estimates of genetic parameters shattering related traits are the primary tasks of sesame breeding for shattering resistance. Information on estimates of heritability and genetic advance is a prerequisite for establishing an appropriate selection method and predicting the expected response due to selection. High heritability estimates reveal a close relationship between the genotype and the phenotype, whereas the value of genetic gain measures the predicted response due to selection [10]. The best conditions for selection are those with high genetic advance and high heritability [11]. So far, information on the extent of variability and estimates of the genetic parameters for shattering and shattering-related traits of sesame are limited. Thus, the present study was conducted to determine genetic variability, heritability and genetic advance for shattering and shattering-related traits.

Table 1. Genotypes tested and their collection region.

GenNo	Genotype	Collection region	GenNo	Genotype	Collection region
1	EBI17697	Oromia	33	ASARC-ACC-SA-017	Benishangul Gumuz
2	EBI17702	Oromia	34	ASARC-ACC-SA-019	Benishangul Gumuz
3	EBI17703	Oromia	35	ASARC-ACC-SA-020	Benishangul Gumuz
4	EBI17704	Oromia	36	ASARC-ACC-SA-022	Benishangul Gumuz
5	EBI17708	Oromia	37	ASARC-ACC-SG-005	Benishangul Gumuz
6	EBI23548	Benishangul Gumuz	38	ASARC-ACC-SG-013	Benishangul Gumuz
7	EBI23565	Benishangul Gumuz	39	ASARC-ACC-SG-018	Benishangul Gumuz
8	EBI28301	Amhara	40	GK-012 (1)	Benishangul Gumuz
9	EBI28302	Amhara	41	GK-012 (2)	Benishangul Gumuz
10	EBI28303	Amhara	42	GM-012 (1)	Benishangul Gumuz
11	EBI28304	Amhara	43	GM-012 (2)	Benishangul Gumuz
12	EBI28306	Amhara	44	Gondar-1	*
13	EBI28308	Amhara	45	HM-012 (1)	Amhara
14	EBI28309	Amhara	46	HM-012 (2)	Amhara
15	EBI28316	Amhara	47	Humera-1	
16	EBI28318	Amhara	48	KG-012 (1)	Oromia
17	EBI28320	Amhara	49	KG-012 (2)	Oromia
18	EBI202514	Benishangul Gumuz	50	MG-012 (1)	Benishangul Gumuz
19	EBI207957	Gambella	51	MG-012 (2)	Benishangul Gumuz
20	Abasena	*	52	MT-023 (1)	Benishangul Gumuz
21	ASARC-ACC-S-001	Benishangul Gumuz	53	MT-075 (1)	Amhara
22	ASARC-ACC-S-003	Benishangul Gumuz	54	Setit-1	*
23	ASARC-ACC-S-004	Benishangul Gumuz	55	Setit-2	*
24	ASARC-ACC-S-006	Benishangul Gumuz	56	TM-023 (2)	Benishangul Gumuz
25	ASARC-ACC-S-010	Benishangul Gumuz	57	TZ-013 (1)	Amhara
26	ASARC-ACC-S-022	Benishangul Gumuz	58	TZ-013 (2)	Amhara
27	ASARC-ACC-SA-002	Benishangul Gumuz	59	TZ-054 (1)	Amhara
28	ASARC-ACC-SA-007	Benishangul Gumuz	60	TZ-054 (2)	Amhara
29	ASARC-ACC-SA-008	Benishangul Gumuz	61	ZT-013 (1)	Amhara
30	ASARC-ACC-SA-009	Benishangul Gumuz	62	ZT-013 (2)	Amhara
31	ASARC-ACC-SA-011	Benishangul Gumuz	63	ZT-054 (1)	Amhara
32	ASARC-ACC-SA-016	Benishangul Gumuz	64	ZT-054 (2)	Amhara

Note: *= Improved variety

2. Materials and Methods

2.1. Description of Experimental Site

In 2019 cropping season, the experiment was carried out in the Pawe Agricultural Research Center research station, which is situated in the Metekel zone of Ethiopia's Benishangul Gumuz region. The Pawe Agricultural Research Center is located about 562 kilometers to the northwest of Addis Ababa. Its coordinates are 11°18' N latitude and 36°24' E longitude. The location is 1120 meters above sea level with a mean annual rainfall of 1586 mm. The mean annual minimum and maximum temperature are 16.50°C and 32.60°C, respectively.

2.2. Genotypes Evaluated and Design Used

The lists of genotypes included in the experiment are presented in Table 1. Sixty-four genotypes which consisted of five improved varieties and 59 accessions which have been obtained from the Ethiopian Biodiversity Institute (EBI), Werer Agricultural Research Center (WARC), and Assosa Agricultural Research Center (AsARC) were evaluated using 8 x 8 lattice design with two replications. The intra and inter row spacing was 10 cm and 40 cm, respectively. Fertilizer (121 kg ha^{-1} NPS) and weeding were applied uniformly.

2.3. Data Collected

Data were recorded on a plot, plant and capsule basis per each

replicate. Data on days to first capsule-opening (DFCO) and days to 90% maturity (DM) were collected on a plot basis. In order to examine the uniformity in capsule-ripening, the range in days between the day of first capsule opening and 90% maturity (DM-DFCO) was computed by subtracting the number of days to first capsule opening from the number of days to 90% maturity.

On five random plants, plant-based data were recorded on number of capsules plant^{-1} (CPP), and number of opened-capsules plant^{-1} (OCPP). The percentage of opened-capsules plant^{-1} (POCPP) was computed as follows:

$$POCPP = \left(\frac{OCPP}{CPP}\right) 100$$

Five opened-capsules were investigated for the length of opened-capsule (LOC) in mm, the length of cracking on opened-capsule (LCOC) in mm, the number of seeds-dropped opened-capsule^{-1} (SDPOC), the number of seeds dropped opened-capsule^{-1} while the capsule is inverted (SDPOCI), and the number of seeds retained opened-capsule^{-1} (SRPOC). The percentage of cracking on opened-capsule (PCOC) was calculated as follows:

$$PCOC = \left(\frac{LCOC}{LOC}\right) 100$$

The percentage of seed retention opened-capsule^{-1} (PSR), upward shattering opened-capsule^{-1} (UpWSh), downward shattering opened-capsule^{-1} (DwWSh), and rate of shattering (RSh) were calculated as follows:

$$PSR = \left(\frac{SPOC}{SDPOC+SDPOCI+SPOC}\right) 100$$

$$UpWSh = \left(\frac{SDPOC}{SDPOC+SDPOCI+SPOC}\right) 100$$

$$DwWSh = \left(\frac{SDPOCI}{SDPOC+SDPOCI+SPOC}\right) 100$$

$$RSh = \left(\frac{SDPOC+SDPOCI}{SDPOC+SDPOCI+SPOC}\right) 100$$

2.4. Data Analysis

Analysis of variance (ANOVA) was conducted using R software [12] via *PBIB. test* function in the agricolae package [13]. A model applied in the ANOVA was:

$$Y_{ijk} = \mu + Rep_i + Block_j (Rep_i) + Gen_k + e_{ijk}$$

where yijk denotes an observed effect, μ denotes the mean, rep$_i$ denotes the ith replicate, and block$_j$ (rep$_i$) denotes the jth incomplete block within the ith replicate, gen$_k$ is the kth genotypic effect, and e$_{ijk}$ is the experimental error. As implemented by Syukur *et al.* [14], the variance components and coefficients of variation were calculated using the mean squares of the ANOVA. According to Deshmukh *et al.* [15], phenotypic and genotypic coefficients of variance were categorized as low (0–10%), moderate (10–20%), and high (>20%). Broad-sense heritability (H^2) was computed as a proportion of genotypic variance and phenotypic variance [16]. Heritability estimates were considered as low (<20%), moderate (20%–50%), and high (>50%) by using Syukur *et al.* [14] categorization. Genetic advance (GA) and genetic advance as a percentage of the mean (GAM) were calculated adopting the formula of Johnson *et al.* [17]. Following the classifications of Johnson *et al.* [17], the estimates of genetic gain as a percentage of the mean were classified as low (0–10%), moderate (10%–20%), and high (>20%).

3. Result and Discussion

The mean and ranges, and mean performance of sesame genotypes for shattering and shattering related traits are presented in Table 2 and Table 4, respectively. The percentage of seed retention opened-capsule^{-1} (PSR) at harvesting ranged from 22.56% (TM-023 (2)) to 73.71% (EBI17703) with mean seed retention opened-capsule (48.80%). The percentage of upward shattering opened-capsule^{-1} (UwWSh) at harvesting ranged from 11.30% (ASARC-ACC-S-001) to 51.17% (EBI28320) with 29.65% of mean upward shattering opened-capsule^{-1}. On the other hand, percentage of downward shattering opened-capsule^{-1} (DwWSh) ranged from 7.78% (HM-012 (2) to 43.97% (EBI17708) with mean downward shattering opened-capsule^{-1} was 21.57%. The rate of shattering opened-capsule^{-1} (RSh), i e., the sum of upward and downward shattering recorded was ranged from 26.20% (EBI17703) to 77.78% (TM-023 (2)) with 51.22% mean rate of shattering. In the present study, wide ranges for both the upward shattering and downward shattering indicated that high loss of yield due to shattering before harvesting and during harvesting. The upward shattering, shattering before harvesting happens due to shaking by wind and mechanical contact by animals, whereas the downward shattering, shattering during harvesting due to mechanical disturbance and inverting of opened-capsules.

Table 2. Mean and range values for shattering and shattering-related traits of sesame genotypes evaluated in 2019 cropping year at Pawe.

Trait	Mean	Range	SEM	LSD at 5%	Coefficient of Variation (%)
DM-DFCO	3.43	0.00-10.50	1.33	3.71	54.94
PCOC (%)	30.33	20.27-58.03	9.81	ns	45.72
POCPP (%)	18.61	2.34-56.03	9.53	ns	72.46
PSR (%)	48.8	22.56-73.71	10.99	ns	31.86
UpWSh (%)	29.65	11.30-51.17	10.36	ns	49.4
DwWSh (%)	21.57	7.78-43.97	8.21	ns	53.85
RSh (%)	51.22	26.20-77.78	10.95	ns	30.25

Note: DM-DFCO=number of days from first capsule-opening up to 90% maturity; PCOC=Percentage of cracking on opened-capsule; POCPP=Percentage of opened-capsule plant^{-1}; PSR=Seed retention opened-capsule^{-1}; UpWSh=Upward shattering opened-capsule^{-1}; DwWSh=Downward shattering opened-capsule^{-1}; and RSh=Rate of shattering opened-capsule^{-1}; SEM=standard error of adjusted means; LSD=least significant difference; and ns=non-significant

Analysis of variance revealed significant difference ($P<0.05$) among sesame genotypes for the number of days from first capsule-opening up to 90% maturity (Table 3). Significant difference among sesame genotypes for the number of days from first capsule-opening up to 90% maturity indicated the existence of sesame genotypes which had uniform capsule ripening. Due to uniform capsule ripening, sesame may avoid shattering from bottom capsules while farmers wait for capsules on the branches and tips of the plant to become mature. On the other hand, harvesting sesame at different levels of capsule maturity deteriorates the uniformity of seeds in terms of size and color. Thus, selection of sesame genotypes with minimum number of days from first capsule-opening up to 90% maturity might enhance the uniformity of seeds in terms of size and color. However, the mean squares of the ANOVA showed non-significant difference ($P>0.05$) among sesame genotypes for the percentage of opened-capsules plant^{-1} (POCPP), Percentage of cracking on opened-capsule^{-1} (PCOC), percentage of seed retention opened-capsule^{-1} (PSR), percentage of upward shattering opened-capsule^{-1} (UwWSh), percentage of downward shattering opened-capsule^{-1} (DwWSh), and rate of shattering (RSh). Thus, the result of the experiment pointed out low scope of improvement for shattering resistance through the evaluation and selection of landraces. Almost all of the sesame varieties grown in Ethiopia are shattering type [4]. Sesame breeders pursue sesame genotypes with desirable traits in order to minimize seed yield loss resulting from shattering.

Table 3. *Mean squares of shattering and shattering-related traits of sesame genotypes evaluated in 2019 cropping year at Pawe.*

	Replication	Block (Replication)	Genotype	Intra-block error	Effective error
Degree of freedom	1	14	63	49	49
DM-DFCO	25.38	3.45	6.35*	3.55	
PCOC (%)	66.77	232.33	151.15^{ns}	183.79	192.33
POCPP (%)	28.35	79.72	252.54^{ns}	181.76	
PSR (%)	252.82	412.44	232.49^{ns}	218.85	241.68
UwWSh (%)	102.71	234.53	216.81^{ns}	209.57	214.53
DwWSh (%)	35.79	147.79	128.00^{ns}	131.71	134.9
RSh (%)	259.86	421.51	235.55^{ns}	216.6	240

Note: DM-DFCO=number of days from first capsule-opening up to 90% maturity; PCOC=Percentage of cracking on opened-capsule; POCPP=Percentage of opened-capsules plant^{-1}; PSR=Seed retention opened-capsule^{-1}; UpWSh=Upward shattering opened-capsule^{-1}; DwWSh=Downward shattering opened-capsule^{-1}; and RSh=Rate of shattering opened-capsule^{-1}; *=significant difference among genotypes ($P<0.05$); and ns=non-significant difference among genotypes ($P>0.05$)

Table 4. *Mean performance of sesame genotypes for shattering and shattering-related traits at Pawe in 2019 cropping year.*

Genotype	DM-DFCO	PCOC (%)	POCPP (%)	PSR (%)	UwWSh (%)	DwWSh (%)	RSh (%)
ASARC-ACC-SG-013	1.5	34.8	5.1	70.8	20.2	9.3	29.1
EBI17697	2.5	51.4	10.5	63.0	23.7	14.0	37.0
ASARC-ACC-SA-011	3.0	25.4	10.8	29.7	48.1	25.4	70.0
ASARC-ACC-SA-008	5.5	24.0	6.9	42.6	44.2	17.5	57.4
ASARC-ACC-SA-019	4.0	49.3	6.9	54.2	22.7	25.4	45.8
Gondar-1	4.0	26.5	9.5	40.9	29.3	34.3	58.8
EBI28306	10.5	22.6	19.7	39.7	40.6	15.5	60.4
ASARC-ACC-SG-018	2.5	21.4	9.2	54.5	27.7	19.0	45.4
ASARC-ACC-S-003	2.0	32.6	20.3	48.6	15.3	36.5	50.2
EBI28318	0.5	38.0	8.8	41.0	30.8	22.8	59.5
EBI17704	2.5	26.0	11.2	57.6	25.8	19.5	42.2
EBI23548	6.0	39.3	17.3	44.2	19.3	41.8	55.6
EBI17703	2.0	24.3	9.8	73.7	13.0	13.0	26.2
MG-012 (2)	3.0	38.7	20.2	42.8	41.0	19.8	57.0
EBI17702	3.0	58.0	5.5	44.4	18.4	36.2	55.7
EBI17708	3.0	23.9	7.4	46.8	11.4	44.0	55.3
ASARC-ACC-S-001	2.5	24.5	4.5	62.7	11.3	30.0	37.1
EBI28320	7.5	24.6	25.6	35.0	51.2	12.6	64.9
EBI28316	2.5	22.0	9.0	31.8	40.3	25.6	68.4
ASARC-ACC-SA-002	2.0	30.1	11.1	60.4	20.4	16.7	39.9
ASARC-ACC-SA-017	3.5	26.7	20.8	40.4	28.4	31.7	59.3
EBI202514	3.5	22.9	13.8	39.3	26.3	35.8	60.8
ASARC-ACC-SA-007	2.5	26.6	10.9	58.9	23.1	19.7	39.5
EBI23565	2.5	33.9	8.8	64.0	14.9	20.8	35.8
EBI28301	2.0	38.0	19.9	47.7	29.6	20.4	52.4
ASARC-ACC-SA-016	3.5	32.9	18.4	49.0	29.1	24.0	50.9

Genotype	DM-DFCO	PCOC (%)	POCPP (%)	PSR (%)	UwWSh (%)	DwWSh (%)	RSh (%)
GK-012 (2)	3.5	48.4	8.7	51.7	31.4	13.7	48.5
MT-023 (1)	3.0	23.6	28.3	46.0	25.0	31.4	53.8
ASARC-ACC-SG-005	5.0	21.2	18.9	53.4	19.2	26.8	46.7
GK-012 (1)	2.5	48.4	12.2	70.7	22.1	9.3	29.1
ASARC-ACC-SA-020	3.5	33.7	19.1	54.6	17.8	25.1	45.5
ASARC-ACC-S-022	2.5	43.9	16.7	44.0	32.4	23.6	55.9
ASARC-ACC-S-004	1.5	29.5	4.8	50.2	42.4	9.1	52.3
ASARC-ACC-SA-009	2.5	28.9	8.4	48.2	38.4	14.8	51.6
MG-012 (1)	3.5	34.2	32.2	62.4	22.9	16.0	37.3
ASARC-ACC-SA-022	3.5	24.3	6.6	34.2	44.7	22.0	65.6
GM-012 (1)	4.0	25.2	20.0	35.9	26.9	35.2	64.2
EBI207957	4.0	37.3	18.3	45.6	39.8	14.1	54.5
Setit-1	3.0	26.8	10.4	57.7	17.8	20.8	42.6
HM-012 (1)	7.5	22.0	56.0	67.0	18.9	20.2	32.8
EBI28308	2.0	38.9	19.1	49.1	35.8	11.4	51.1
EBI28302	3.5	27.5	28.0	43.8	30.5	24.7	56.4
EBI28309	2.5	25.2	46.8	53.7	25.6	19.3	46.3
Humera-1	4.5	45.4	11.4	56.0	24.6	21.9	43.7
TM-023 (2)	4.5	29.1	17.1	22.6	50.2	22.8	77.8
MT-075 (1)	4.0	26.3	36.3	38.0	50.1	11.4	62.0
EBI28303	2.5	25.6	16.7	58.1	29.6	12.8	41.8
TZ-013 (2)	6.5	24.0	34.9	41.5	31.9	32.2	58.4
Setit-2	5.0	23.4	38.3	34.2	37.9	28.7	65.7
ZT-013 (2)	3.5	23.6	20.1	36.2	41.3	22.9	63.0
ASARC-ACC-S-006	2.5	26.2	24.2	43.9	39.7	14.3	56.0
ZT-013 (1)	3.0	24.1	39.6	62.7	21.4	18.9	37.3
HM-012 (2)	2.5	23.5	18.3	67.9	23.0	7.8	32.2
TZ-054 (1)	2.5	26.5	23.0	61.1	20.2	16.1	39.1
TZ-013 (1)	2.5	26.1	9.6	37.7	33.6	22.9	62.7
ASARC-ACC-S-010	1.5	26.5	23.9	54.9	25.0	19.3	45.1
ZT-054 (1)	2.5	42.7	31.1	52.0	31.6	18.4	47.7
Abasena	4.5	31.7	29.5	54.8	29.6	19.7	45.1
EBI28304	9.0	20.3	17.0	36.2	39.8	22.6	64.0
GM-012 (2)	3.0	43.1	21.1	47.8	32.6	16.4	52.6
KG-012 (1)	3.0	23.2	37.3	29.5	50.0	15.9	70.8
ZT-054 (2)	3.0	25.6	28.4	41.4	44.4	12.6	60.6
TZ-054 (2)	3.5	24.3	34.5	44.5	20.4	31.9	55.8
KG-012 (2)	2.0	22.6	2.3	50.2	23.1	22.7	47.9

Note: DM-DFCO=number of days from first capsule-opening up to 90% maturity; PCOC=Percentage of cracking on opened-capsule; POCPP=Percentage of opened-capsules plant^{-1}; PSR=Seed retention opened-capsule^{-1}; UpWSh=Upward shattering opened-capsule^{-1}; DwWSh=Downward shattering and RSh=Rate of shattering opened-capsule^{-1}

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) estimates were higher (>20%) for the number of days from the first capsule-opening up to 90% maturity (DM-DFCO) and percentage of opened-capsules plant^{-1} (POCPP) (Table 5). The highest PCV for the number of days from first capsule-opening up to 90% maturity (DM-DFCO) and the percentage of opened-capsules plant^{-1} (POCPP) indicated the existence of high phenotypic variation among the evaluated sesame genotypes. High PCV and GCV difference was exhibited for the number of days from the first capsule-opening up to 90% maturity (DM-DFCO) and the percentage of opened-capsules plant^{-1} (POCPP). The highest differences between GCV and PCV values indicates the greater contribution of environmental effect on observed phenotype [6, 18]. High PCV but low GCV estimates which

have been recorded on the percentage of cracking on the opened-capsule (PCOC), percentage of seed retention opened-capsule^{-1} (PSR), percentage of upward shattering (UpWSh), percentage of downward shattering (DwWSh), and rate of shattering (RSh) indicated that an observed variation was mainly attributed to the environmental effect. Furthermore, low heritability and genetic advance as percentage of the mean (GAM) estimates for the percentage of cracking on the opened-capsule (PCOC), percentage of seed retention opened-capsule^{-1} (PSR), percentage of upward shattering opened-capsule^{-1} (UpWSh), percentage of downward shattering opened-capsule^{-1} (DwWSh), and rate of shattering opened-capsule^{-1} (RSh) revealed that these traits were attributed to the environmental effects and limited scope to improve sesame for shattering resistance through selection underlying these traits. In addition, the present

study suggests breeders to evaluate sesame for shattering and shattering-related traits based on molecular data rather than

phenotypic evaluation.

Table 5. *Estimates of variances, heritability and genetic advance for shattering and shattering-related traits of sesame genotypes evaluated in 2019 cropping year at Pawe.*

Traits	Genotypic variance (σ_{2g})	Phenotypic variance (σ_{2p})	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability in broad sense (H2bs)	Genetic advance (GA)	Genetic advance as percentage of the mean (GAM)
DM-DFCO	1.40	3.18	34.49	51.95	44.09	1.62	47.19
PCOC (%)	0.00	96.16	0.00	32.33	0.00	0.00	0.00
POCPP (%)	35.39	126.27	31.97	60.40	28.03	6.49	34.87
PSR (%)	0.00	120.84	0.00	22.53	0.00	0.00	0.00
UpWSh (%)	1.14	108.41	3.60	35.12	1.05	0.23	0.76
DwWSh (%)	0.00	67.45	0.00	38.08	0.00	0.00	0.00
RSh (%)	0.00	120.00	0.00	21.39	0.00	0.00	0.00

Note: DM-DFCO=number of days from first capsule-opening up to 90% maturity; PCOC=Percentage of cracking on opened-capsule; POCPP=Percentage of opened-capsules plant[-1]; PSR=Seed retention opened-capsule[-1]; UpWSh=Upward shattering opened-capsule[-1]; DwWSh=Downward shattering and RSh=Rate of shattering opened-capsule[-1]

4. Conclusion

The tested plant materials showed a significant difference in the number of days from first capsule-opening up to days to 90% maturity indicating the presence of sesame genotypes with uniform capsule ripening characteristics. Therefore, genotypes with uniform capsule ripening should be considered in sesame breeding programs to reduce shattering and to produce uniform seeds in terms of size and color. However, the present study suggests the need for the introduction and incorporation of exotic germplasm in Ethiopian sesame breeding programs to develop shattering-resistant varieties. Further, low estimates of heritability and genetic advance as percentage of the mean for shattering and shattering-related traits indicated that an environment had a significant influence on these traits, which recommends breeders to evaluate sesame genotypes for shattering resistance based on molecular data rather than phenotypic data.

Conflicts of Interest

The author declared no competing interests.

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