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Genetic parameters of variability and character association studies for yield and some capsule shattering traits in sesame germplasm

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Abstract
Forty five genotypes of sesame were evaluated to have an idea about their performance and to study the correlation basing on yield and yield related characters including capsule shattering related traits. Analysis of variance indicated highly significant differences among the genotypes with respect to all the characters indicating wide variability. High magnitude of PCV and GCV was recorded for branch number per plant, capsule number per plant, seed weight per capsule, capsule split before and after 4drying, capsule opening before and after drying as well as seed yield per plant. This indicated relatively higher contribution of these characters towards genetic variability. High estimates of heritability were recorded for all characters. High heritability coupled with high genetic advance was recorded for all the characters except days to maturity, plant height and capsule length. Seed yield showed a highly significant and positive correlation with capsule number per plant and plant height. Low to medium capsule split and opening along with medium capsule constriction is a desirable capsule character for developing semi shattering semi shattering sesame genotypes by recombination breeding.

Keywords: Sesame, genetic variability, heritability, character association, capsule shattering

Introduction
Sesame (*Sesamum indicum*L.) is a traditional oilseed crop having immense medicinal and therapeutic properties. The chemical composition of sesame shows that the seed is an important source of oil (50–60%), protein (18–25%), carbohydrates (13.5%) and ash (5%) (Saeed *et al.*, 2015; Gharby *et al.*, 2017) [1, 2]. Around 35% of oil present in sesame consists of monounsaturated fatty acids and 44% polyunsaturated fatty acids. The seed oil exhibits remarkable stability to oxidation due to the presence of antioxidants like sesamol, sesamolin and sesamin (Yoshida & Takagi, 1999) [3] and hence known as “queen of oilseeds”. The quantity and quality of the oil depend on ecological, physiological and genetic factors (Rahman *et al.*, 2007; Ogbonna and Ukaan, 2013) [4, 5]. In spite of its nutritional value, it is not a preferred crop by the farmers as compared to other oilseed crops due to low harvest index, lack of wider adaptability, susceptibility to diseases and pests, indeterminate growth habit, non-synchronous and capsule shattering at maturity (Yol and Uzun, 2012) [6].

Capsule shattering at maturity is one of the major reasons for low yield. Hence developing sesame genotypes with semi shattering habit will reduce seed loss in field at maturity. One of the characters determining semi shatterness is that the capsules should have lower extent of capsule split and higher seed retention capacity during maturity. This will ensure delay opening of mature capsules in the field and release seeds easily on threshing (Langham, 1998) [7]. Therefore, development of semi shattering genotypes with good seed retention capacity will be useful in maintaining seed quality and help in reducing the yield loss due to capsule shattering in the field. However, less information is available on this aspect in sesame.

Realizing the importance of development of semi shattering varieties with high yield potential, the aim of the present study was to study the extent of genetic variability in the sesame germplasm and to examine the nature and magnitude of character association for capsule characters related to shattering among the sesame genotypes for genetic enhancement.

Materials and methods
Experimental material for the present investigation comprised of forty five sesame genotypes screened for capsule shattering characters at the experimental farm of Orissa University of Agriculture and Technology, Bhubaneswar, India during kharif season of the agricultural year 2017-18. The field lay out was done in randomized block design with three replications. Each entry was represented by 2 row plot of 2 m length with a line-to-line spacing of 30 cm apart.

The seeds of genotypes were direct seeded in the rows and later thinned to a single seedling per hill at a distance of 10 cm approximately. All recommended agronomic practices was followed to raise a healthy crop.

A total of twenty characters for yield and its components as well as capsule characters related to shattering were studied in sesame. Observations were recorded on ten quantitative traits, *viz.* days to maturity, plant height, branch number per plant, capsule number per plant, capsule length, capsule width, seed number per capsule, seed weight per capsule, 1000-seed weight and seed yield per plant. Observations were also recorded on ten capsule shattering related traits, *viz.* capsule split before drying of capsules, capsule split after drying of capsules, capsule open before drying of capsules, capsule open after drying of capsules, unattached seed weight, retained seed weight, potential seed weight, unattached seed number, retained seed number and potential seed number.

Observations for days to maturity was recorded on plot basis and observations on other quantitative characters were taken from a sample of five randomly chosen plants per plot and averaged for per plant values. Capsule width was measured with the aid of a dial thickness gauge. A sample of five mature closed capsules was selected randomly from mid portion of plant and the observations on the capsule dimensions (length and width), seed number per capsule, weight of 1000 seed as well as capsule traits related to shattering were recorded as per Dash *et al*. (2018) [8].

The observations recorded for the capsule shattering related traits were used to compute the six shattering parameters viz., extent of capsule split (ECS%), extent of capsule open (ECO%), upright shatter resistance (USR%), inverted shatter resistance (ISR%), capsule constriction (CCON%) and shaker shatter resistance (SSR%). These six shattering parameters were computed based on Langham (1998) [7] and modified for the present study (Dash *et al*., 2018) [8]. Based on the six capsule shattering parameters the genotypes were then classified into three groups i.e non-shattering (NoS), semi-shattering (SeS) or super-shattering (SuS) types, as per the index score method (Singh and Chaudhary, 1977) [9]. The phenotypic and genotypic coefficient of variability was computed as per Burton and Vane (1953) [10]. The values were treated as high, moderate and low as per the categorization proposed by Siva Subramanian and Madhavamenon (1973) [11]. Heritability in broad sense was estimated using the components of variance as suggested by Hanson *et al.* (1956) [12] and categorised as per Johansen *et al.*, (1955) [13]. Genetic advance was worked out as per the formula given by Johansen *et al.* (1955) [13]. Correlation coefficients were evaluated utilizing the formula suggested by Al-jibouri *et al.* (1958) [14].

Results

Genetic variability

The analysis of variance and F-test revealed highly significant difference among the genotypes for all the characters. This indicated the presence of wide genetic variability among the genotypes (Table 1). Information on coefficient of variation is useful in measuring the range of variability present in the characters. The coefficient of variation with respect to different characters among the sesame genotypes ranged from 0.86 to 13.43 (Table 2). The highest variation (13.43) was recorded for seed weight per capsule followed by seed yield per plant (12.60). The lowest variation was recorded in capsule width (0.86) followed by capsule split after drying (1.22).

The estimates of PCV varied from 1.39 percent in days to maturity to 50.51 percent for seed yield per plant. The estimates of GCV showed a similar trend and varied from 1.19 percent for days to maturity to 49.98 percent for seed yield per plant. High magnitude of PCV and GCV in respect of branch number per plant, capsule number per plant, seed weight per capsule, capsule split before and after drying, capsule opening before and after drying and seed yield per plant indicates relatively higher contribution of these characters towards genetic variability. There is narrow difference between PCV and GCV for days to maturity, capsule number per plant, capsule width, seed number per capsule, capsule split before and after drying, capsule opening before and after drying as well as thousand seed weight. Further high GCV was observed for branch per plant, capsule number per plant, seed weight per capsule, capsule split before and after drying, capsule opening before and after drying as well as seed yield per plant.

Heritability and genetic advance

The heritability estimates ranged from 73.02 percent in days to maturity to 99.97 percent in capsule split before drying indicating varied seasonal effect on character expression (Table 2). High estimates of heritability (>70 percent) was obtained for all characters in general signifying predominance of heritable components of variation indicative of efficacy of selection on the basis of phenotypic manifestation of the traits. Expected genetic advance for different characters expressed as percentage of population mean, ranged from 1.79 percent in days to maturity to 87.05 percent in seed yield per plant, at ten percent selection intensity. High expected genetic gain under selection was obtained for branch number per plant (35.59%), capsule number per plant (44.14%), capsule width (28.21%), seed number per capsule (23.97%), seed weight per capsule (42.37%), capsule open and split before and after drying and seed yield per plant (87.05%). For days to maturity it was low (<10%) while for plant height and capsule length, it was medium (10-20 percent). Further high heritability estimates coupled with high genetic advance for all the characters except for days to maturity, plant height and capsule length was observed. This clearly indicates that selection in the desired direction might be quite effective for the remaining eleven characters.

Character association

In most of the character pairs, the genotypic correlations were higher than phenotypic correlations (Table 3). In case of genotypic correlation, highest positive significant association (0.904) was found between branch number per plant and capsule number per plant whereas lowest positive significant association (0.3) was found between capsule length and seed number per capsule. Similarly, in case of phenotypic correlation highest positive significant association (0.879) was found between branch number per plant and capsule number per plant.

At phenotypic level seed yield showed a highly significant and positive correlation with capsule number per plant and plant height. Positive correlation was also found for seed yield with branch number per plant, capsule open and split before drying. At the genotypic level, the correlations of seed yield with other characters followed the similar trend as that were at the phenotypic level. Though the directions of both genotypic and phenotypic correlations were same, the genotypic correlation coefficients were of higher magnitude as compared to phenotypic correlation coefficient in most of the cases.

At both genotypic and phenotypic levels, the association of days to maturity with different traits was positive and negative. The trait had significant negative correlation with capsule open before drying of capsules. The number of branches per plant had significantly positive correlation with capsule number per plant and plant height at both genotypic and phenotypic levels. Capsule number per plant, the most important yield component, showed significant positive correlation with plant height. With rest of the characters it showed positive correlation except for capsule length with which it is negatively correlated. Plant height showed negative association with all the characters except for capsule width and seed number per capsule with which it exhibited positive association. Capsule length showed significant positive association with seed number per capsule, seed weight per capsule and capsule split after drying. It showed negative association with capsule opening before drying. The association of capsule width with different traits was positive and negative. It showed significant positive association with thousand seed weight. Seed number per capsule exhibited significant positive association with capsule length, seed weight per capsule, capsule open and split after drying at both genotypic and phenotypic levels. Seed weight per capsule showed significant positive association with capsule length, capsule open and split after drying as well as thousand seed weight. At both genotypic and phenotypic levels thousand seed weight showed positive significant association with capsule width and seed weight per capsule. It showed negative association with plant height and capsule open before drying. It showed positive association with rest of the characters.

Capsule split as well as capsule open before and after drying are important characters that determine the shattering habit of sesame capsules. Capsule opening before drying showed significant positive association with capsule opening after drying, capsule split before and after drying and only positive association with branch number per plant, capsule number per plant, capsule width, seed number and weight per capsule. Capsule opening after drying exhibited significant positive association with capsule split before and after drying. Capsule split before drying exhibited significant positive correlation with capsule split after drying as well as capsule opening before and after drying of the capsules. It showed positive association with branches per plant, capsules per plant, capsule length, seed number per capsule and seed weight per capsule. Capsule split after drying showed significant positive association with capsule length, seed number per capsule, seed weight per capsule, capsule opening before and after drying of capsules and capsule split before drying. It showed negative correlation with days to maturity, capsule number per plant and plant height. In respect of most of the character pairs, genotypic correlations were higher than phenotypic correlations.

Capsule shattering parameters

The estimates of the six parameters for the 45 sesame genotypes that provide a quantitative measurement in determining the shatter resistance is presented in Table 4.

The extent of capsule split along the suture ranged from 0.59% to 78.65% in with an overall mean of 20.87%. The extent of capsule opening exposing the membrane and seeds ranged from 5.65% to 86.65%. The values for upright shatter resistance ranged from 13.96% to 163.13% while inverted shatter resistance ranged from 5.42% to 123.76%. Capsule constriction ranged from 3.01% to 99.28%. Shaker shatter resistance ranged from 2.72% to 96.99% with an overall mean of 48.88%.

The genotypes were scored for these parameters following index score method. Basing on the total index score for these six parameters the 45 genotypes were further grouped into the low (1), medium (2) and high (3) score groups. The genotypes in low score group are non-shattering, in medium group semi shattering and under high group are super shattering types.

Table 1: ANOVA of yield and its components and some capsule characters related to shattering in sesame

Characters	Mean sum of Squares	
	Blocks (2)	**Genotypes (44)**
Days to maturity (DM)	10.669**	4.324**
Branches per plant (B/P)	0.079	0.730**
Capsules per plant (C/P)	0.790	448.47**
Plant height (PH) (cm)	74.092	315.396**
Capsule length (CL) (cm)	1.293**	0.242**
Capsule width (CW) (mm)	1.254**	3.899**
Seed number per capsule (SN/C)	7.982**	174.14**
seed weight per capsule (SW/C) (gm)	0.001**	0.001**
Capsule split before drying (CS-1) (cm)	0.39**	0.17**
Capsule split after drying (CS-2) (cm)	0.659**	0.538**
Capsule open before drying (CO-1) (cm)	0.681**	1.665**
Capsule open before drying (CO-2) (cm)	0.26**	0.747**
Thousand seed weight (TSW) (gm)	0.001	0.18**
Seed yield per plant (SYP) (gm)	0.346**	1.573**

** indicate significance at 1% levels of probability respectively; Figure in parentheses indicate degrees of freedom for corresponding sources of variation.

Table 2: Mean, range, genotypic and phenotypic coefficient of variations and genetic advance percentage over mean of fourteen characters

Characters	Mean	Range	CV (%)	GCV (%)	PCV (%)	h^2 (%)	GA (% of mean)
DM	86.14	84.00-88.33	1.25	1.19	1.39	73.02	1.79
B/P	2.26	1.33-3.20	10.15	20.99	21.8	92.78	35.59
C/P	47.30	23.53-75.87	7.14	25.46	25.85	97.01	44.14
PH	88.45	67.70-106.53	6.92	10.90	11.61	88.16	18.01
CL	2.56	1.98-3.06	2.38	10.99	11.08	98.46	19.20
CW	7.08	2.74-8.47	0.86	16.04	16.04	99.90	28.21
SN/C	55.62	42.07-72.27	1.83	13.66	13.7	99.40	23.97
SW/C	0.08	0.04-0.13	13.43	25.19	26.35	91.34	42.37
CS-1	1.72	0.12-3.04	1.29	43.25	43.25	99.97	76.10
CS-2	2.28	1.07-3.06	1.22	21.85	21.86	99.90	38.43
CO-1	0.51	0.11-1.04	5.53	46.50	46.61	99.53	81.65
CO-2	1.08	0.50-2.68	1.32	38.96	38.97	99.96	68.55
TSW	1.45	0.85-1.93	1.41	16.87	16.89	99.77	29.66
SY/P	1.43	0.48-3.69	12.60	49.98	50.51	97.92	87.05

Bold figures indicate minimum and maximum values

Table 3: Phenotypic (r_p) and genotypic (r_g) correlations among yield and its components and some capsule characters related to shattering in sesame

Character		DM	B/P	C/P	PH	CL	CB	SNC	SWC	CO-1	CO-2	CS-1	CS-2	TSW
B/P	r_p	-0.079	-0.131	-0.092	0.044	0.150	0.171	0.120	-0.290	-0.017	-0.057	-0.026	0.137	-0.429
	r_g	-0.090	-0.150	-0.124	0.051	0.174	0.203	0.148	-0.341	-0.020	-0.068	-0.029	0.163	-0.510
C/P	r_p		0.879**	0.517**	-0.231	0.054	0.053	0.134	0.216	0.046	0.219	0.040	0.190	0.263
	r_g		0.904**	0.567**	-0.243	0.055	0.052	0.151	0.227	0.048	0.227	0.042	0.197	0.275
PH	r_p			0.698**	-0.315	0.151	0.126	0.150	0.070	-0.102	0.070	-0.105	0.189	0.323*
	r_g			0.745**	-0.325	0.152	0.127	0.162	0.071	-0.105	0.071	-0.107	0.192	0.329*
CL	r_p				-0.231	0.045	0.067	-0.022	-0.155	-0.307	-0.174	-0.266	-0.118	0.480**
	r_g				-0.254	0.047	0.074	-0.025	-0.162	-0.327	-0.184	-0.240	-0.126	0.509**
CB	r_p					0.026	0.298*	0.420**	-0.191	0.032	0.032	0.402**	0.240	-0.134
	r_g					0.023	0.300*	0.448**	-0.190	0.031	0.032	0.406**	0.243	-0.137
SNC	r_p						-0.068	0.015	0.113	0.047	-0.050	0.193	0.326*	-0.166
	r_g						-0.069	0.016	-0.112	0.047	-0.050	0.194	0.327*	-0.168
SWC	r_p							0.732**	0.036	0.360*	0.168	0.331*	0.234	-0.209
	r_g							0.770**	0.036	0.361*	0.169	0.333*	0.235	-0.212
CO-1	r_p								0.013	0.307*	0.276	0.381**	0.675**	-0.258
	r_g								0.013	0.322*	0.289*	0.398**	0.708**	-0.270
CO-2	r_p									0.420**	0.752**	0.371*	-0.037	0.183
	r_g									0.421**	0.753**	0.370*	-0.038	0.185
CS-1	r_p										0.441**	0.532**	0.191	-0.152
	r_g										0.441**	0.533**	0.191	-0.154
CS-2	r_p											0.671**	0.142	0.062
	r_g											0.671**	0.142	0.063
TSW	r_p												0.224	-0.088
	r_g												0.225	-0.089
SY/P	r_p													-0.365
	r_g													-0.368

* and ** indicate significance at 5% and 1% levels probability respectively

Table 4: Frequency of genotypes on performance ranking for six capsule shattering parameters in 45 sesame genotypes

Parameters (in percent)	Mean	Range	Number of genotypes		
			score 1	score 2	score 3
Extent of capsule split (ECS)	20.87	0.59-78.65	31	10	4
Extent of capsule opening (ECO)	22.37	5.65-86.65	37	6	2
Upright shatter resistance (USR)	96.22	13.96-163.13	28	7	10
Inverted shatter resistance (ISR)	44.35	5.42-123.76	23	19	3
Capsule constriction (CCON)	60	3.01-99.28	24	16	5
Shaker shatter resistance (SSR)	88	2.72-96.99	15	15	15
Shattering type =			Non shattering	Semi shattering	Super shattering

Discussion

The estimates of mean, range, genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance reflect information to different parameters of variability observed in all characters. Information on coefficient of variation is useful in measuring the range of variability present in the characters. High values of PCV and GCV were noted for branch number per plant, capsule number per plant, seed weight per capsule, capsule split before and after drying, capsule opening before and after drying and seed yield per plant. This indicates relatively higher contribution of these characters towards genetic variability. Similar results for other characters were reported by Shekhawat *et al*. (2013) [15], Bharathi *et al*. (2014) [16], Chandramohan (2014) [17], and Hika *et al*. (2015) [18].

The narrow difference between PCV and GCV for days to maturity, capsule number per plant, capsule width, seed number per capsule, capsule split before and after drying, capsule opening before and after sun drying as well as thousand seed weight indicated that these characters were less affected by environment. Further high GCV for branch per plant, capsule number per plant, seed weight per capsule, capsule split before and after drying, capsule opening before and after drying as well as seed yield per plant indicates presence of better scope of genetic improvement in these traits which could be achieved using simple selection procedures. Higher value of both PCV and GCV has been reported for number of primary branches by Tripathi *et al*. (2013) [19], Vanishree *et al*. (2013) [20], Bharathi *et al*. (2014) [16], Ismaila and Usman (2014) [21] and Hika *et al*. (2015) [18]; for capsules per plant by Narayanan and Murugan (2013) [22], Bharathi *et al.* (2014) [16], Ismaila and Usman (2014) [21], and Shabana *et al.* (2015) [23]; for the character seeds per capsule by Narayanan and Murugan (2013) [22], Bharathi *et al.* (2014) [16] and Hika *et al.* (2015) [18].

For all characters, PCV was higher than GCV. Similar type of results is reported by Ahadu (2012) [24], Narayanan and Murugan (2013) [22]. This implies that the characters had interacted with the environment to some extent for their expression. However, the narrow difference between PCV and GCV indicated that the characters were influenced by the environment to a very less extent.

Heritability is a measure of the genetic relationship existing between parent and progeny. It is useful in prediction of yield from generation to generation. Moreover, the estimates of heritability offer a quantitative measurement in defining the relative importance of genetic and environmental factors in the expression of a particular quantitative attribute. So the heritability estimates depend upon the amount of genetic variation in the population and the environmental conditions under which the population is evaluated (Allard, 1960). In other words, heritability may be regarded as an index to quantify the effect of the selection. The heritability estimates ranged from 73.02 percent in days to maturity to 99.97 percent in capsule split before drying indicating varied seasonal effect on character expression. High estimates of heritability was obtained for all characters in general indicating predominance of heritable components of variation suggesting effectiveness of selection on the basis of phenotypic expression of the traits. High heritability for one or more characters was also reported by Ismaila and Usman (2012) [21], Ahadu (2012) [24], Tripathi *et al.* (2013) [19], Ahmed and Ahmed (2013) [25], Vanishree *et al*. (2013) [20], Ismaila and Usman (2014) [21], Aladi *et al.* (2014) [26], Bharathi *et al.* (2014) [16], Mahmoud and Zeinab (2015) [27] and Hika *et al.* (2015) [18]. Contradictory results have also been found in some cases, which might be due to the number of genotypes studied, variability present in the population and the type of environment in which the varieties were evaluated.

The genetic advance as percent of mean is a useful indicator of the progress that can be expected as a result of exercising selection on the pertinent population. The traits with high heritability and high genetic advance indicate the control of additive gene action and selection may be effective for these characters. It was high for all characters except for days to maturity, plant height and capsule length hence points to the predominance of additive effects (Panse, 1957) [28] and can be taken as unit characters for effective selection. Low genetic gain was obtained for days to maturity. Similar results for days to maturity was also reported by Suvarna *et al*. (2008) [29] and Sivaprasad and Yadavalli (2012) [30]. High heritability coupled with high genetic advance for one or more characters in sesame was also reported by Kumhar *et al.* (2008) [31], Ismail and Usman (2012) [21], Yirgalem *et al.* (2012) [32], Gangadhara *et al.* (2012) [33], Ukaan and Ogbonna (2012) [34], Tripathi *et al.* (2013) [19], Vanishree *et al*. (2013) [20], Bharathi *et al.* (2014) [16], Shekhawat *et al*. (2013) [15], Chandramohan (2014) [17], Mahmoud and Zeinab (2015) [28], Hika *et al.* (2015) [18], and Shabana *et al.*(2015) [23].

Character association study helps to know the suitability of various characters for selection, because selection of a particular trait may induce positive or negative changes in the associated characters. The correlation coefficients provide useful information for choice of characters in a selection program. Estimates of genotypic correlation along with phenotypic correlation not only give a clear picture of the extent of inherent association but also indicate how much of the genetically expressed correlation is influenced by environment. Unfavourable associations between the desired attributes under selection may limit genetic advance. In the present study, relatively higher magnitude of correlation coefficient indicated a strong inherent association among various characters (Table 3). Therefore, selection based on the phenotype would be effective. The difference in magnitude of association between two sets at phenotypic and genotypic level indicates that environment factors play a significant role in changing the magnitude of correlation coefficients both at genotypic and phenotypic level. Similar results were reported by Sumathi *et al.* (2007) [35] and Shekhawat *et al.* (2013) [15].

Seed yield showed a highly significant and positive correlation with capsule number per plant and plant height. Positive correlation was also found for seed yield with branch number per plant, capsule open and split before drying. Similar results of highly significant and positive correlation of seed yield with component traits were obtained by Ismaila and Usman (2012) [21] and Hika *et al.* (2015) [18]. Seed yield per plant exhibited negative correlation with days to maturity, capsule length, capsule width, seed number and weight per capsule, capsule split and open after drying and 1000-seed weight. According to NeWall and Eberhart (1961) [36] when two characters show negative phenotypic and genotypic correlation it would be difficult to exercise simultaneous selection for these characters in the development of a variety. Hence, under such situations, judicious selection programme is necessary for concurrent improvement of such vital developmental and component characters.

Most of the semi shattering genotypes recorded low to medium capsule split and opening. This character helps in retaining the seeds within the capsule on maturity and easy release of seeds on inverting. In addition, these genotypes exhibited medium capsule constriction. The non-shattering genotypes recorded low capsule open after drying which must have prevented the release of seeds from capsules during threshing. The genotypes exhibiting medium to high shaker shatter resistance are grouped under non-shattering types. The super shatter genotypes recorded high values for most of the parameters. Similar observations for super shattering characters were observed by Maneekao *et al.* (2001) [37].

Conclusion

In the present study, sufficient genetic variability existed among the genotypes for seed yield and other traits as well as capsule shattering characters. High magnitude of PCV and GCV recorded for branch number per plant, capsule number per plant, seed weight per capsule, capsule split before and after drying, capsule opening before and after drying and seed yield per plant indicated relatively higher contribution of these characters towards genetic variability. Heritability in broad sense was high for all characters. Genetic gain under selection was high for all characters except for days to maturity, plant height and capsule length hence these eleven traits can be considered as unit characters for effective selection and can be exploited in breeding programs for developing high yielding sesame genotypes. Low to medium capsule split and opening along with medium capsule constriction is a desirable capsule character for developing semi shattering semi shattering sesame genotypes by recombination breeding.

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