Journal of Experimental Biology and Agricultural Sciences

<http://www.jebas.org>

ISSN No. 2320 – 8694

INDUCED POLYGENIC VARIABILITY BY COMBINING HYBRIDIZATION AND CHEMICAL MUTAGEN IN F_1M_1 GENERATION OF SESAME HYBRIDS

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Received – April 28, 2019; Revision – June 30, 2019; Accepted – July 18, 2019

Available Online – August 05, 2019

DOI: [http://dx.doi.org/10.18006/2019.7\(4\).343.348](http://dx.doi.org/10.18006/2019.7(4).343.348)

KEYWORDS

Distribution parameters

EMS

F_1M_1 generation

Polygenic variability

Sesame hybrids

ABSTRACT

The present investigation was undertaken to estimate the combined effects of hybridization and Ethyl Methane sulfonate (EMS) on variability of polygenic traits associated with productivity in F_1M_1 generation of sesame crop. Three popular and well adapted sesame varieties were crossed and three non-reciprocal crosses were made. These F_{1s} seeds were divided into two lots and one lot from each cross were used for EMS treatment. F_{1s} seeds of each cross were presoaked separately in distilled water overnight followed by treating with 0.5 percent freshly prepared EMS solutions for 3 hours. Seeds of total nine populations (three EMS treated populations " $F_1^1M_1$ ", three respective crosses as controls " F_{1s} " and three parents) were shown in a randomized block design (RBD) with 3 replications during the summer season, 2017. Observations were recorded on four polygenic traits and statistical analysis like ANOVA of mean, standard deviation and CV was carried out and the significant differences among various treatments were tested by 'F' and t - tests. Reduced mean and increased standard deviation was observed for plant height whereas increased mean and standard deviation was observed for number of capsules per plant and seed yield per plant in EMS treated $F_1^1M_{1s}$. Increased in variability in mutant populations for above characters might be due to breakage of linkage between favorable and unfavorable genes. Three F_1M_1 populations used in this study showed differential sensitivity with respect to different quantitative characters. The changes in different polygenic traits of mutant populations than respective controls must have arisen through induced micro-mutations. The relative magnitudes of genetic change in the hybrids as a result of chemical mutagen would be better known from analyses in later generations.

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Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

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1 Introduction

Sesame is an ancient oil yielding crop and world total cultivation area under sesame was 9,398,770 ha and producing 4.76 million tons (FAOSTAT, 2013). In 2016, Sesame seeds production was 6.1 million tons globally and countries like Tanzania, Myanmar, India and Sudan were the leading producer with the production of 940,221 t, 812,952 t, 797, 700 t and 721,000 t respectively (FAOSTAT, 2017). Genetic variation is a pre- requirement in order to make selections effective. An achievement in any breeding program depends on both amount and nature of variation. Natural variation (arising through natural hybridization and spontaneous mutations) is often not useful as such and therefore not adequate for the purpose of breeding. Therefore breeder has to create variation of the desired kind in order to be able to effect improvement.

Hybridization followed by selection in advance segregating generations is the basic approach in any breeding program for increasing productivity in self-pollinated crops. This method is equally applicable and has been extensively used for transferring and combining desirable qualitative characters such as disease resistance found in different varieties (Govindarasu, 1995). The basis of improvement of quantitative traits by this method is transgressive segregation resulting from recombination of desirable genes of the parental varieties (Rieseberg & Ellstrand, 1993). The nature and magnitude of variation in segregating generations following hybridization depend on the genetic architecture the parental varieties. Apart from genetic architecture, the tight linkage between polygenes controlling the interested characters could be an obstruction to release the useful variability (Alarmelu, 1992). The present investigation in sesame crop was undertaken to assess the combined effects of hybridization and EMS treatment on variability of polygenic traits related to productivity. This has been done through a critical analysis of variation in yield and its components in F_1M_1 generation. The aim of this study is to throw light on the usefulness of combining hybridization and EMS treatment for improvement of quantitative traits including yield.

2 Materials and Methods

The essential materials of the present study consisted of three sesame varieties which were well adapted to Odisha climate *viz.*, Nirmala, Prachi and Amrit. Important characteristics features of these varieties are specified in Table 1. These selected varieties were crossed and three non-reciprocal crosses (F_{1s}) were made. For Ethyl Methanesulfonate (EMS) treatment, crossed seeds were presoaked separately in distilled water overnight followed by treating with 0.5 percent freshly preparer EMS solutions for 3 hours. Dose selection of this chemical mutagen, was based upon the review of Begum & Dasgupta (2010), Begum & Dasgupta (2015) and Kumari et al. (2016). Ethyl Methanesulfonate (EMS) treated seeds were washed carefully for 1hour in running tap water in order to remove the residual effect of the EMS. After careful washing the treated seeds along with parents and respective controls were sown immediately to grow the F_1M_1 generation in a randomized block design (RBD) with three replications during summer, 2017 at EB-II section of Department of Plant Breeding and Genetics, OUAT. Designation of parents, treatments and controls (F_{1s}) in F_1M_1 generation is presented in Table 2. Sowing was done in plots with 7 rows of 3 meters each with spacing of 30 cm X 10 cm. 2-3 seeds were dibbled per hill in order to ensure crop stand and thinning was done later on in order to maintain one seedling per hill. Recommended cultural practices like fertilizer application (@ 30 kg N, 60 kg P_2O_5 and 40 kg K_2O) and need-based plant protection measures were practice. Observations were recorded on four traits, *viz.*, plant height, total number of primary branches per plant, number of capsules per plant and single plant yield. Single plant observation was recorded for all the four characters using a sample size of 30 randomly selected competitive plants per plot. The basic material was investigated for polygenic variability in F_1M_1 generation along with corresponding controls.

Analysis of variance was carried out on plot mean values for each of the four characters and the significance of differences among treatments tested by F test. The significance of difference between two means was tested by t-test through computation of CD.

Table 1 Place of origin, pedigree and characteristics of the parental varieties

Variety	Place of origin	Pedigree	Plant type	Maturity duration (days)	Capsule type	Seed colour	Oil content (%)	Average yield (q/ha)
Nirmala	OUAT, Bhubaneswar	Mutant of B-67	Basal branching	80-85	Small and hairy	Grey white	42-44	7.00-7.50
Prachi	OUAT, Bhubaneswar	Mutant of B-67	Profuse branching	85-90(Kharif) 75-80 (Rabi/Summer)	Narrow, Oblong and less hairy	Black	42-45	9.00-10.00
Amrit	OUAT, Bhubaneswar	XU-2 × Krishna	Profuse branching	82-85	Glabrous and compact	Light Brown	43-46	7.50-8.50

Table 2 Designation of various treatments and controls in F_1M_1 generation

Treatment symbol	Description
V_1	Variety 1 (Nirmala)
V_2	Variety 2 (Prachi)
V_3	Variety 3 (Amrit)
1F_1	F_1 generation of Cross 1
2F_1	F_1 generation of Cross 2
3F_1	F_1 generation of Cross 3
1F_1M_1	F_1M_1 generation following EMS treatment of F_1 seeds of Cross 1
2F_1M_1	F_1M_1 generation following EMS treatment of F_1 seeds of Cross 2
3F_1M_1	F_1M_1 generation following EMS treatment of F_1 seeds of Cross 3

The superscript of F_1 is not a part of filial generation notation

Standard deviation and CV were estimated for each treatment replication wise for four characters. ANOVA of mean, standard deviation and CV was carried out and the significance of differences among treatments tested by ' F' and t-tests following Bahl et al. (1968).

3 Results and Discussion

Recombination breeding through hybridization and selection has been widely used for sesame improvement for many years. But

recombination breeding has brought forth only limited progress in the improvement of sesame due to close linkages between desirable and undesirable component characteristics. In this situation, the mutagenic treatment of heterozygous material such as hybrid seeds has recently become popular, assuming that more and different genetic variations can be created because of the greater mutability of hybrids (heterozygous) than pure lines (homozygotes) and breaking up of undesirable linkages by mutation in the segregating populations which are an obstruction to recombination.

The present study aimed at making an evaluation of the usefulness of combining hybridization and induction of mutation by treating hybrids with chemical mutagen, Ethyl Methanesulfonate (EMS) for enlarging variability of quantitative traits in sesame. This has been done through a critical analysis of variation in seed yield per plant and its components (plant height, number of primary branches per plant and capsules per plant) in F_1M_1 generation.

ANOVA of means for four characters is presented in Table 3. F test indicated significant differences among treatments in means of all characters except plant height. ANOVA of standard deviation and CV of four characters in F_1M_1 generation are presented in Tables 4 and 5. F test indicated significant differences among treatments for number of capsules per plant and seed yield per plant for standard deviation. For CV number of

Table 3 ANOVA of means for four characters in F_1M_1 generation (Mean sum of squares)

Sl. No.	Characters	Source of variation (df)		
		Blocks (2)	Treatments (8)	Error (16)
1.	Plant height (cm)	3.314	41.743	21.939
2.	Number of primary branches per plant	0.160	0.225*	0.066
3.	Number of capsules per plant	3.478	180.524**	43.387
4.	Seed yield per plant (g)	0.935	1.603*	0.539

*Significant at 5% level of probability and ** Significant at 1% level of probability; figures in parentheses indicates degrees of freedom (df) for corresponding sources of variation

Table 4 ANOVA of standard deviation for four characters in F_1M_1 generation (Mean sum of squares)

Sl. No.	Characters	Source of variation (df)		
		Blocks (2)	Treatments (8)	Error (16)
1.	Plant height (cm)	31.857	5.649	4.821
2.	Number of primary branches per plant	0.108	0.021	0.017
3.	Number of capsules per plant	10.027	44.638*	14.891
4.	Seed yield per plant (g)	0.199	0.866**	0.201

*Significant at 5% level of probability and ** Significant at 1% level of probability; figures in parentheses indicates degrees of freedom (df) for corresponding sources of variation

Table 5 ANOVA of CV for four characters in F_1M_1 generation (Mean sum of squares)

Sl. No.	Characters	Source of variation (df)		
		Blocks (2)	Treatments (8)	Error (16)
1.	Plant height (cm)	18.141	4.033	2.369
2.	Number of primary branches per plant	26.220	68.333*	25.619
3.	Number of capsules per plant	12.365	26.511	16.031
4.	Seed yield per plant (g)	5.799	66.176*	17.362

*Significant at 5% level of probability and ** Significant at 1% level of probability

Table 6 Range, mean and standard deviation of plant height (cm) in F_1M_1 generation

Treatment	Range	Mean	Standard deviation
V_1	113.90-164.87	137.60	12.373
V_2	95.83-169.83	136.50	10.662
V_3	103.89-155.89	130.12	12.914
1F_1	104.07-180.07	143.43	12.942
$^1F_1^1M_1$	105.18-173.74	135.78*	12.710
2F_1	105.64-159.84	136.91	11.718
$^2F_1^1M_1$	107.81-167.81	137.91	13.006
3F_1	110.58-169.58	138.38	11.660
$^3F_1^1M_1$	100.10-159.43	132.60*	15.238*
CD at 5%	-	3.82	1.79
SE(m)	-	2.70	1.27

* Significantly different from control

Table 7 Range, mean and standard deviation of number of primary branches per plant in F_1M_1 generation

Treatment	Range	Mean	Standard deviation
V_1	0.82-5.82	2.49	1.084
V_2	0.91-4.08	2.61	0.880
V_3	0.72-6.09	2.59	1.133
1F_1	0.79-4.89	2.52	0.981
$^1F_1^1M_1$	0.61-5.61	2.81*	0.942
2F_1	1.40-5.70	2.87	0.998
$^2F_1^1M_1$	1.00-6.17	3.33*	1.062
3F_1	0.67-5.67	2.57	1.069
$^3F_1^1M_1$	0.86-5.19	2.96*	0.995
CD at 5%	-	0.21	0.11
SE(m)	-	0.15	0.08

* Significantly different from control

primary branches per plant and seed yield per plant indicated significant differences among treatments. The significant treatment differences in standard deviation and CV could be due to mutagenic and/or physiological effects of chemical mutagen, Ethyl Methanesulfonate (EMS).

Range, mean and standard deviation of plant height, number of primary branches per plant, number of capsules per plant and seed yield per plant in F_1M_1 generation is presented in Table 6 to Table 9. Only two $F_1^1M_1$ populations ($^1F_1^1M_1$ and $^3F_1^1M_1$) showed reduced mean height value than respective controls and population $^2F_1^1M_1$ showed no change in mean value than control 2F_1 (Table 6). Only one population $^3F_1^1M_1$ showed increased standard deviation than 3F_1 . Reduced expression of plant height may be due to physiological effect of chemical mutagen. All the $F_1^1M_{1s}$ showed significant positive shift in mean of number of primary branches per plant (Table 7). No significant shift in standard deviation was observed for any of the $F_1^1M_{1s}$ than the respective controls F_{1s} for this character.

Only population $^2F_1^1M_1$ showed positive significant shift in standard deviation and mean than the respective controls 2F_1 for number of capsules per plant (Table 8). Populations $^1F_1^1M_1$ and $^3F_1^1M_1$ showed non significant shift in standard deviation and mean of this character. All the $F_1^1M_{1s}$ populations ($^1F_1^1M_1$, $^2F_1^1M_1$ and $^3F_1^1M_1$) showed greater range for seed yield per plant (Table 9). All the $F_1^1M_{1s}$ populations showed positive significant shift in standard deviation than the respective controls F_{1s} . Positive shift in mean was observed for population $^2F_1^1M_1$, whereas population $^3F_1^1M_1$ showed non significant shift in mean for seed yield per plant.

From the results of the first generation with respect to the quantitative traits discussed so far, it was reported that EMS brought out reduction in plant height and increased standard deviation. These findings were in agreement with the reports of Aliyu et al. (2017), Kumar & Yadav (2010), Sanghani et al. (2016), Saha & Paul (2017) and Ravichandran & Jayakumar (2015).

Table 8 Range, mean and standard deviation of number of capsules per plant in F₁M₁ generation

Treatment	Range	Mean	Standard deviation
V ₁	30.32-133.92	68.89	24.167
V ₂	35.24-109.81	63.78	15.943
V ₃	32.47-128.47	73.93	23.055
¹ F ₁	33.11-140.11	75.08	22.942
¹ F ₁ ¹ M ₁	35.83-139.77	79.23	25.498
² F ₁	35.46-167.46	77.26	25.582
² F ₁ ¹ M ₁	35.10-181.27	91.53*	29.187*
³ F ₁	29.68-157.08	80.81	27.897
³ F ₁ ¹ M ₁	33.60-151.60	77.53	26.358
CD at 5%	-	5.38	3.15
SE(m)	-	3.80	2.23

* Significantly different from control

Table 9 Range, mean and standard deviation of seed yield per plant (g) in F₁M₁ generation

Treatment	Range	Mean	Standard deviation
V ₁	3.25-13.52	6.49	2.413
V ₂	2.54- 9.42	5.95	1.596
V ₃	3.10-12.39	6.57	1.999
¹ F ₁	3.30-14.20	6.34	2.058
¹ F ₁ ¹ M ₁	2.93-16.21	7.51*	2.854*
² F ₁	3.80-14.47	6.99	2.131
² F ₁ ¹ M ₁	2.97-17.88	8.43*	3.336*
³ F ₁	3.22-14.42	6.90	2.487
³ F ₁ ¹ M ₁	3.75-17.53	7.20	2.868*
CD at 5%	-	0.60	0.37
SE(m)	-	0.42	0.26

* Significantly different from control

EMS brought out higher mean values and standard deviation of number of capsules per plant and seed yield per plant. This might be due to breaking of unfavorable physiological conditions leading to stimulatory effect. These findings were in agreement with the reports of Sanghani et al. (2016) and Saha & Paul (2017) for number of capsules per plant and seed yield per plant, and Birara et al. (2014) for number of capsules per plant. This effect might be due to the heterotic effects of mutagen.

The three F₁¹M₁s used in the study showed differential sensitivity with respect to quantitative characters in the first generation after EMS treatment. Similar results on differential response by

mutagenic treatment for polygenic characters were reported by Anbarasan et al. (2015) and Ravichandran & Jayakumar (2015).

Conclusion

The analysis in F₁M₁ generation showed that hybrids responded to the mutagen, Ethyl Methanesulfonate (EMS) and increased in variability was noticed in mutant populations compared to corresponding hybrids. The changes in mean and standard deviation of quantitative traits in the mutant populations compared to the respective controls must have come about through induced micro-mutations. The relative magnitudes of genetic change in the hybrids as a result of chemical mutagen, EMS would be better known from analyses in later generations.

Conflict of Interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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