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# EVALUATION OF GENETIC PARAMETERS IN $M_4$ AND $M_5$ GENERATIONS OF SESAME MUTANT LINES

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## SUMMARY

Selection of genotypes based on plant height and number of capsules per plant with a high value of forecasted genetic conditions would be an effective method for improvement of sesame as an economical oil crop. The experimental material consisted of 18 lines $M_4$ generation and 39 lines $M_5$ generation of sesame mutant lines. There were two experiments carried out to obtain information on genetic parameters and relationship of some agronomical characteristics of $M_4$ and $M_5$ generations of sesame mutant lines treated with gamma rays, after selection. Analysis showed that selection can significantly decrease the genotypic and phenotypic variance of seed yield and yield components in $M_4$ and $M_5$ generations. The genotypic and phenotypic correlation coefficients significantly increase between seed yield and plant height, the number of primary branches, the number of secondary branches, the number of nodes per plant, number of capsules per plant, and 1000-seed weight after selection.

**Key words:** Genetic parameter, seed yield, selection, *Sesamum indicum* L.

**Key findings:** In self-pollinated crops like sesame, induced mutation by gamma rays irradiation can successfully be utilized for altering and improvements genetic variation in considerable enhancement of economic yield. Sesame selection is an integral part of breeding program made significant contributions to increase the genotypic and phenotypic correlation coefficients.

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## INTRODUCTION

Sesame is important commodity produce healthy oil, considered as source of proteins, natural antioxidants such as sesamin and sesamol, phosphorus, potassium, calcium, sodium, iron, vitamins B and E (Weiss, 1971; Johnson *et al*., 1979; Suja *et al*., 2004). *Sesamum indicum* L. is an annual plant and autogamous species. The success in genetic improvement of the crop depends on the availability of genetic variability. The value of genetic diversity needs to be understood before setting the breeding and selection methods (Scossiroli, 1977; Laurentin and Karlovsky, 2006; Furat and Uzun, 2010).

Gamma irradiation has drawn an attention as a new and rapid method for improving the quantitative characteristics of many crops. Gamma irradiation has been widely applied in terms of biological effects. Following Rajput (2001), sesame appears to be very suitable material for inducing useful mutations, induced mutations of manipulating genetic variability can also be profitably exploited for improving the quantitative and qualitative traits in sesame.

Sesame selection based on plant height and number of branches per plant, which had the significant positive contribution with seed yield per plant, was among the most important traits which accounted for more than half of the all phenotypic variation in sesame and might be more efficient for suitable sesame genotype screening. The understanding of the relationship between yield and its components is crucial for selection process (Biabani and Pakniyat, 2008; Akbar *et al*., 2011; Yol and Uzun, 2012). The study aims to obtain information on genetic variability and genotypic correlation of some agronomical characteristics of $M_4$ and $M_5$ generations of sesame mutant lines after selection based on plant height and number of capsules per plant.

## MATERIALS AND METHODS

The research materials were $M_4$ and $M_5$ generations from two types of local *Sesamum indicum* L. (black and white) mutant lines derived from homogeneous seeds treated with eight doses (100-800 Gy) of gamma rays (Co-60) individually. The study was carried out at Sleman, Yogyakarta (7°16′ N; 110°21′ E), with an altitude of 193 m above sea level (MASL). The type of soil in field trials is Inceptisol which contained of 9.73% clay, 33.63% silt and 56.64% sand with the soil pH is approximately 6.34.

The study was carried out in two stages. The first stage is to cultivate and select the $M_4$ generation begins at the vegetative stage, in March-August 2015. The second stage is to cultivate $M_5$ generation in November 2015-April 2016. The $M_5$ generation is the result of individual selection in $M_4$ generation and derived from every sesame mutant lines, based on plant height (criteria mean±SD = 199.75±12.75 cm) and the number of capsules per plant (criteria mean±SD = 166.68±64.35) (Table 1).

Each $M_4$ and $M_5$ mutant lines were grown in four row of 5 m length at a distance of 40 cm between the rows and 25 cm between the plants within the rows, arranged in a completely randomized design. Sesame was sown at two seeds per hole to ensure adequate crop stand. Increasing soil humidity was provided by means of furrow irrigation. Two ton/ha organic fertilizers, a dose of 100 kg/ha nitrogen, phosphorus, and potassium was applied as composite fertilizers at sowing.

Quantitative observations were recorded on yield-related components. Trait selection and measurement techniques were based on descriptors of sesame according to IPGRI and NBPGR (2004). Statistical parameters such as the overall mean, the mean of squares among lines, genotypic (GCV) and phenotypic coefficient of variances (PCV) were analyzed according to the method described by Singh and Chaudhary (1977) and Steel and Torrie (1980). To test the variability difference between population $M_4$ and $M_5$ will be done by comparing the genotypic and phenotypic variance both population using Fischer test for variance similarity.

Genetic variability for all properties is calculated from the phenotypic and genotypic coefficient of variation (Singh and Chaudhary, 1977). The phenotypic and genotypic coefficient of variation classified for high, moderate and small based on Johnson *et al*. (1955). The phenotypic coefficient of variation is divided into three major categories: high (PCV > 50%), moderate (25% < PCV ≤ 50%) and small (PCV ≤ 25%). The genotypic coefficient of variation is classified into three major categories: high (GCV > 14.5%), moderate (5% < GCV ≤ 14.5%) and small (GCV ≤ 5%).

The ratio of total genetic variation to the total phenotypic variation is called the broad sense heritability (Singh and Chaudhary, 1977; Kearsey and Pooni, 1996). The broad sense heritability is classified into three major categories: high (H > 50%), moderate (20% < H ≤ 50%) and small (H ≤ 20%) (Knight, 1979).

Genotypic and phenotypic correlation can be estimated using the formula of Falconer (1960) and Singh and Chaudhary (1977). To see the pattern of the relationship between the characteristics using a correlation analysis will be examined based on the *t-test* (Singh and Chaudary, 1977; Falconer, 1960; Kearsey and Pooni, 1996). To evaluate the correlation between the traits of $M_4$ and $M_5$ population,

**Table 1.** Sesame mutant lines were selected based on plant height and number of capsules per plant in some gamma irradiation dosages treatments.

| Type | Treatments | Lines of $M_4$ | Lines of $M_5$ | Type | Treatments | Lines of $M_4$ | Lines of $M_5$ |
|---|---|---|---|---|---|---|---|
| Black | | | 1 | White | Control | 10 | 39 |
| | | | 2 | | | | 17 |
| | Control | 1 | 3 | | | | 18 |
| | | | 4 | | 100 Gy | 11 | 19 |
| | | | 5 | | | | 20 |
| | | | 6 | | | | 21 |
| | 100 Gy | 2 | 7 | | 200 Gy | 12 | 22 |
| | | | 8 | | | | 23 |
| | 200 Gy | 3 | 9 | | 300 Gy | 13 | 24 |
| | 300 Gy | 4 | 10 | | | | 25 |
| | 400 Gy | 5 | 11 | | | | 26 |
| | 500 Gy | 6 | 12 | | 400 Gy | 14 | 27 |
| | | | 13 | | | | 28 |
| | 600 Gy | 7 | 14 | | | | 29 |
| | 700 Gy | 8 | 15 | | 500 Gy | 15 | 30 |
| | 800 Gy | 9 | 16 | | | | 31 |
| | | | | | 600 Gy | 16 | 32 |
| | | | | | | | 33 |
| | | | | | 700 Gy | 17 | 34 |
| | | | | | | | 35 |
| | | | | | | | 36 |
| | | | | | 800 Gy | 18 | 37 |
| | | | | | | | 38 |

coefficient correlation is compared based on Draper and Smith (1998). Analysis of variance and correlation between characteristics is processed using SAS software facility (Littell *et al*., 2006).

## RESULTS AND DISCUSSION

### Effect of mutagens and selections on qualitative traits

The pattern of inheritance for a qualitative trait is typically monogenetic, which means that the trait is only influenced by a single gene. The gamma rays very little influence the qualitative traits. In general, the qualitative $M_4$ and $M_5$ generations of sesame characterization and evaluation studies indicate characteristic of $M_4$ generation will be followed by a descent in $M_5$ generation of sesame mutant lines. The plant material used is indeterminate, type with description acropetal flowering plant, the plants continue to grow and produce flowers and capsules as long as conditions permit. Originally indeterminate plant growth in sesame has different developmental stages of capsules in a plant. Capsules on middle and low position of stem are ripened but those of late bloom high on the stem remain immature (Figure 1). According to Uzun *et al.* (2013), this characteristic causes unwanted agricultural issues such as non-synchronous maturity and incompatibility to combine harvesting.

The inflorescence of sesame was observed, in black and white type $M_4$ and $M_5$ of sesame showed the same nature on number of flowers per leaf axil is one, color of interior corolla is white, and exterior corolla is white with pink shading. The thread in the corolla is the short filament of a stamen. The object around the base of ovary is the nectary. The inflorescence is a raceme and the fruit is a capsule. The flowers arise in the axils of the leaves and on the upper portion of the branches and stem.

$M_4$ $M_5$

**Figure 1.** Plant characteristics

$M_4$ $M_5$

**Figure 2.** Inflorescence and capsule characteristics

In all lines of $M_4$ and $M_5$ generations indicate capsule characteristics in number of locules per capsule observed on capsules from the middle of main stem is four. Capsule arrangement which record the number of capsules per node is monocapsular. Anthocyanin coloration of capsule when recorded in immature stage of the capsule is absent (Figure 2).

**Effect of mutagens and selections on quantitative traits**

Genetic parameters for quantitative traits observed are presented in Table 2. High genetic variability of plant population is very important raw material for developing new lines and plant breeding program. Success in any breeding program depends on the amount of genotypic variance present for the different characteristics in a population. The genotypic variance is the variation in genotypes between different lines as a result of genetic mutation or gene flow. The genotypic variance in $M_4$ generation presented a range between 0.12 (1000-seed weight) to 3970.10 (number of capsules/plant). The genotypic variance in $M_5$ generation showed a range between 0.04 (1000-seed weight) to 739.19 (biomass yield/plant).

High estimates of genotypic variance, in both, $M_4$ and $M_5$ generations, were recorded for number of capsules/plant (3970.10 and 576.36, respectively) and biomass yield/plant (996.16 and 739.19, respectively). Maximum phenotypic variance was observed for the number of capsules/plant (10636.10 and 4534.06, respectively) followed by plant height (832.70 and 282.61, respectively) and biomass yield/plant (4907.46 and 4933.69, respectively) in both generations, in the $M_4$ and $M_5$ mutant populations. The lowest phenotypic variance value was recorded for 1000-seed weight (0.44 and 0.33, respectively) in both generations (Table 2).

To see the effect of selection, the mean, genotypic and phenotypic variance were studied. The overall mean of seed yield and yield components in comparison of the $M_4$ and $M_5$ generations of sesame mutant lines showed value less than one for number of primary branches (0.93), number of nodes/plant (0.81), number of nodes to first flower (0.60), stem height from base to first branch (0.31), and stem height from base to first capsule (0.58) which means an increase in the mean value of the $M_5$ than $M_4$.

The genotypic and phenotypic variance of seed yield and yield components after selection in comparison to the $M_4$ and $M_5$ generations of sesame mutant lines showed the significant low value in plant height (32.49 and 2.95, respectively), number of secondary branches (2.62 and 1.17, respectively), number of nodes to first flower (14.42 and 2.02, respectively), number of capsules/plant (6.89 and 2.35, respectively), 1000-seed weight (3.47 and1.36, respectively), and seed yield/plant (5.60 and 3.00, respectively) (Table 2). That means that an increase in the value of the treated populations was an important indicator of the efficiency of the selection in inducing genetic variability.

Populations showed good potential in increasing genotypic variability for the traits, indicating that these characteristics can be transmitted to future generations and that potential gain could be achieved through selection in early generations for desired genetic improvement, these results agree with Usharani and Kumar (2016).

## Effect of mutagens and selections on GCV and PCV

Seed yield is a complex multi component characteristic and is greatly influenced by genetic system and various environmental conditions. Therefore, it is necessary to separate the total variation into heritable and non-heritable components with the help of genetic parameters i.e. genotypic and phenotypic coefficient of variation (GCV and PCV). The genetic changes in quantitative characteristics could be realized with an increased variance in $M_4$ and $M_5$ generations. GCV and PCV in $M_4$ and $M_5$ generation were recorded for high value for stem height from base to first branch (30.96%, 54.40% and 23.40%, 54.99%, respectively), number of capsules/ plant (44.90%, 73.49% and 27.16%, 76.17%, respectively), biomass yield/plant (28.37%, 62.96% and 35.26%, 91.09, respectively), and seed yield/plant (36.68%, 66.19% and 33.59%, 82.78%, respectively) (Table 3).

Higher coefficient of variation suggested that these characteristics are under the influence of genetic control, in turn offers good scope for selection. These results are in agreement with those of Parameshwarappa *et al*. (2009); Firmansyah *et al*. (2012); Usharani and Kumar (2016). This indicates the lesser influence of environment in the expression of these characteristics.

Selection based on plant height and number of capsules per plant can change genotypic coefficient of variation among the traits in $M_4$ and $M_5$ generations of sesame mutant lines in plant height (5.99/moderate and 1.07/small, respectively), number of nodes to first flower (72.66/high and 11.48/moderate, respectively) and stem height from base to first capsule (14.82/high, 12.78/moderate, respectively).

The phenotypic coefficient of variation in $M_4$ and $M_5$ generations also changed in the number of primary branches (45.34/moderate and 57.72/high, respectively), the number of secondary branches (84.60/high and 15.46/small, respectively), the number of nodes/plant (24.34/small and 26.87/moderate, respectively), the number of nodes to first flower (75.97/high and 32.10/moderate, respectively), and the stem height from base to the first capsule (26.05/moderate and 23.41/small, respectively) (Table 3). The level of genetic variability in a population will be determined by the balance of the effect of selection and mutation.

**Table 2.** Genetic parameters for quantitative traits in sesame mutant lines.

| Characteristics | Generation | μ | MSe | $\sigma^2_g$ | $\sigma^2_p$ |
|---|---|---|---|---|---|
| Plant height (cm) | $M_4$ | 202.83 | 684.99 | 147.67 | 832.70 |
| | $M_5$ | 198.94 | 277.95 | 4.55 | 282.61 |
| | Comparison | 1.02** | 2.46** | 32.49** | 2.95** |
| Number of primary branches | $M_4$ | 4.68 | 2.51 | 2.00 | 4.51 |
| | $M_5$ | 5.03 | 7.31 | 1.10 | 8.43 |
| | Comparison | 0.93 | 0.34 | 1.82 | 0.53 |
| Number of secondary branches | $M_4$ | 5.07 | 11.03 | 7.39 | 18.42 |
| | $M_5$ | 2.57 | 12.89 | 2.82 | 15.76 |
| | Comparison | 1.97** | 0.86 | 2.62** | 1.17** |
| Number of nodes/plant | $M_4$ | 23.26 | 24.34 | 7.65 | 32.00 |
| | $M_5$ | 28.71 | 47.99 | 11.50 | 59.49 |
| | Comparison | 0.81 | 0.51 | 0.67 | 0.54 |
| Number of nodes to first flower | $M_4$ | 5.44 | 1.45 | 15.64 | 17.09 |
| | $M_5$ | 9.07 | 47.99 | 1.08 | 8.47 |
| | Comparison | 0.60 | 0.03 | 14.42** | 2.02** |
| Stem height from base to first branch (cm) | $M_4$ | 10.50 | 22.03 | 10.58 | 32.61 |
| | $M_5$ | 33.57 | 278.99 | 61.72 | 340.77 |
| | Comparison | 0.31 | 0.08 | 0.17 | 0.10 |
| Stem height from base to first capsule (cm) | $M_4$ | 53.52 | 131.45 | 62.93 | 194.35 |
| | $M_5$ | 91.67 | 323.28 | 137.27 | 460.58 |
| | Comparison | 0.58 | 0.41 | 0.46 | 0.42 |
| Number of capsules/plant | $M_4$ | 140.34 | 6665.61 | 3970.10 | 10636.10 |
| | $M_5$ | 88.40 | 3945.62 | 576.36 | 4534.06 |
| | Comparison | 1.59** | 1.69 | 6.89** | 2.35** |
| Biomass yield/plant (g) | $M_4$ | 111.26 | 3910.69 | 996.16 | 4907.46 |
| | $M_5$ | 77.11 | 4178.25 | 739.19 | 4933.69 |
| | Comparison | 1.44** | 0.94 | 1.35 | 0.99 |
| 1000-seed weight (g) | $M_4$ | 3.56 | 0.32 | 0.12 | 0.44 |
| | $M_5$ | 3.28 | 0.29 | 0.04 | 0.33 |
| | Comparison | 1.09** | 1.09 | 3.47** | 1.36** |
| Seed yield/plant (g) | $M_4$ | 24.53 | 182.71 | 81.07 | 263.81 |
| | $M_5$ | 11.33 | 73.32 | 14.49 | 87.98 |
| | Comparison | 2.17** | 2.49** | 5.60** | 3.00** |

Comparison = Comparison between $M_4$ and $M_5$, μ = the overall mean, MSe = the mean squares within lines, $\sigma^2_g$ = genotypic variance, $\sigma^2_p$ = phenotypic variance, *significant at $P \leq 0.05$, ** $P \leq 0.01$.

**Effect of mutagens and selection on heritability**

Heritability is a concept that summarizes how much of the variation in a trait is due to variation in genetic factor. In both, $M_4$ and $M_5$ generations, observations were made on 11 morphological characteristics, the genetic parameters such as heritability for each treatment were estimated and compared with those of the control for each characteristic separately (Table 3).

Broad sense heritability of seed yield and yield components in $M_4$ generation sesame mutant lines showed high value for number of nodes to first flower (91.49%), small was observed for plant height (1.61%) and moderate on all the other characteristics. $M_5$ generation estimates heritability ranged from 1.61% (plant height) to 29.80% (stem height from base to first capsule). Generally, broad sense heritability in the $M_5$ generation showed small value for all the traits, except for stem height from base to the first capsule (moderate), this is because the effect of selection which requires uniformity in the population.

Following Khan *et al.* (2010); Uzun *et al*. (2013); Begum and Dasgupta (2014), genetic

**Table 3.** The coefficients of variation and heritability for seed yield and yield related characteristics in sesame mutant lines.

| Characteristics | Genera -tion | GCV (%) | | PCV (%) | | H (%) | |
|---|---|---|---|---|---|---|---|
| Plant height (cm) | $M_4$ | 5.99 | (moderate) | 14.23 | (small) | 17.73 | (small) |
| | $M_5$ | 1.07 | (small) | 8.45 | (small) | 1.61 | (small) |
| Number of primary branches | $M_4$ | 30.16 | (high) | 45.34 | (moderate) | 44.33 | (moderate) |
| | $M_5$ | 20.85 | (high) | 57.72 | (high) | 13.05 | (small) |
| Number of secondary branches | $M_4$ | 53.64 | (high) | 84.60 | (high) | 40.12 | (moderate) |
| | $M_5$ | 65.36 | (high) | 15.46 | (small) | 17.87 | (small) |
| Number of nodes/plant | $M_4$ | 11.91 | (moderate) | 24.34 | (small) | 23.92 | (moderate) |
| | $M_5$ | 11.81 | (moderate) | 26.87 | (moderate) | 19.32 | (small) |
| Number of nodes to first flower | $M_4$ | 72.66 | (high) | 75.97 | (high) | 91.49 | (high) |
| | $M_5$ | 11.48 | (moderate) | 32.10 | (moderate) | 12.79 | (small) |
| Stem height from base to first branch (cm) | $M_4$ | 30.96 | (high) | 54.40 | (high) | 32.45 | (moderate) |
| | $M_5$ | 23.40 | (high) | 54.99 | (high) | 18.11 | (small) |
| Stem height from base to first capsule (cm) | $M_4$ | 14.82 | (high) | 26.05 | (moderate) | 32.38 | (moderate) |
| | $M_5$ | 12.78 | (moderate) | 23.41 | (small) | 29.80 | (moderate) |
| Number of capsules/plant | $M_4$ | 44.90 | (high) | 73.49 | (high) | 37.33 | (moderate) |
| | $M_5$ | 27.16 | (high) | 76.17 | (high) | 12.71 | (small) |
| Biomass yield/plant (g) | $M_4$ | 28.37 | (high) | 62.96 | (high) | 20.30 | (moderate) |
| | $M_5$ | 35.26 | (high) | 91.09 | (high) | 14.98 | (small) |
| 1000-seed weight (g) | $M_4$ | 9.83 | (moderate) | 18.53 | (small) | 28.23 | (moderate) |
| | $M_5$ | 5.78 | (moderate) | 17.40 | (small) | 11.05 | (small) |
| Seed yield/plant (g) | $M_4$ | 36.68 | (high) | 66.19 | (high) | 30.73 | (moderate) |
| | $M_5$ | 33.59 | (high) | 82.78 | (high) | 16.47 | (small) |

CV = genotypic coefficient of variation, PCV = phenotypic coefficient of variation; H = broad sense heritability

information like heritability of several yield contributing characteristics have a positive correlation with yield and would be of great value enabling development of new genotypes with improve quality traits and having broadened genetic base.

### Effect of mutagens and selection on genotypic and phenotypic correlation coefficients

Knowledge of the genetic association between seed yield and other traits can help to improve the efficiency of selection and important to study the relationships seed yield with numerous interrelated characteristics.

The genotypic and phenotypic correlation coefficients in $M_4$ and $M_5$ generations for seed yield had positively and significantly increased with number of primary branches ($r_g$ = 0.3334 and 0.4701, $r_p$ = 0.3071 and 0.5290, respectively), number of secondary branches ($r_g$ = 0.3435 and 0.5875, $r_p$ = 0.3235 and 0.5530, respectively), number of nodes to the first flower ($r_g$ = 0.3516 and 0.0702, $r_p$ = 0.1386 and 0.0813, respectively) and 1000-seed weight ($r_g$ = 0.1767 and 0.2623, $r_p$ = 0.1867 and 0.3287, respectively) (Table 4). A positive and significant correlation was observed between seed yield and other traits meant that with the increase in yield related characteristics there was a significant increase in seed yield of sesame mutant lines. This study indicates that the nature and extent of variability was generated in yield and important yield components through induced mutagenesis can be used successfully to develop new mutant varieties of sesame.

It had negatively and significantly correlated with stem height from base to first branch. Our results agreed with similar positive correlation by Yol *et al*. (2010), Aristya and Taryono (2016) who reported that sesame selection based plant height and number of capsules/plant which have the significant positive contribution to seed yield/plant were among the most important traits for suitable sesame genotype screening.

**Table 4.** Genotypic and phenotypic correlation coefficients for seed yield and yield related characteristics in sesame mutant lines.

| Characteristics | Correlation | $M_4$ | $M_5$ | Comparison $M_4$ and $M_5$ |
|---|---|---|---|---|
| Plant height (cm) | $r_g$ | 0.0743 | 0.0509 | 0.68 |
| | $r_p$ | 0.1022** | 0.1658** | -1.89* |
| Number of primary branches | $r_g$ | 0.3334** | 0.4701** | -4.77** |
| | $r_p$ | 0.3071** | 0.5290** | -7.91** |
| Number of secondary branches | $r_g$ | 0.3435** | 0.5875** | -9.20** |
| | $r_p$ | 0.3235** | 0.5530** | -8.37** |
| Number of nodes/plant | $r_g$ | 0.1783 | 0.4433 | -8.63** |
| | $r_p$ | 0.2086** | 0.4177** | -6.80** |
| Number of nodes to first flower | $r_g$ | 0.3516** | 0.0702** | 8.66** |
| | $r_p$ | 0.1386** | 0.0813** | 1.69* |
| Stem height from base to first branch (cm) | $r_g$ | -0.2006** | -0.1421** | -1.76* |
| | $r_p$ | -0.2258** | -0.1363** | -2.7** |
| Stem height from base to first capsule (cm) | $r_g$ | -0.0167 | 0.0134 | -0.88 |
| | $r_p$ | -0.0184 | 0.0098 | -0.82 |
| Number of capsules/plant | $r_g$ | 0.7300 | 0.6875 | 2.49** |
| | $r_p$ | 0.6745** | 0.7836** | -6.87** |
| Biomass yield/plant (g) | $r_g$ | 0.6136 | 0.8280 | -13.61** |
| | $r_p$ | 0.7819** | 0.8618** | -7.29** |
| 1000-seed weight (g) | $r_g$ | 0.1767** | 0.2623** | -2.62** |
| | $r_p$ | 0.1867** | 0.3287** | -4.44** |

$r_g$ = the genotypic correlation coefficient, $r_p$ = the phenotypic correlation coefficient, *significant at $P \leq 0.05$, **$P \leq 0.01$.

Correlations between characteristics can simplify the measurement of phenotypic selection, because selection on a particular trait produces not only a direct effect on the distribution of that trait in a population, but also produces indirect effects on the distribution of correlated characteristics, was also worked out according to Wirnas *et al.* (2006).

## The comparison genetic parameter of $M_4$ and $M_5$ generations on sesame yield components

The method to determine some important components of sesame yield can be judged by comparing the explainable effect of yield component on seed yield/plant. This analysis can decide minimum number of characteristics, which are probably effective in improving yield, and will help breeders to handle the number of characteristics in the selection procedure (Table 5).

Generally, the genotypic and phenotypic variance of seed yield and yield components after selection in comparison of the $M_4$ and $M_5$ generations of sesame mutant lines showed the significant low value in plant height, number of secondary branches, number of nodes to first flower, number of capsules/plant, 1000-seed weight, and seed yield/plant. That means an increase in the value of the treated populations, was an important indicator of the efficiency of the selection in inducing genetic variability.

Selection based on plant height and number of capsules per plant can change genotypic coefficient of variation among the traits in $M_4$ and $M_5$ generations of sesame mutant lines in plant height, number of nodes to first flower and stem height from base to first capsule. The phenotypic coefficient of variation in $M_4$ and $M_5$ generations also changed in number of primary branches, number of secondary branches, number of nodes/plant, number of nodes to first flower, and stem height from base to first capsule. The level of genetic variability in a population will be determined by the balance of the effect of selection and mutation.

Broad sense heritability after selection in $M_4$ and $M_5$ generations of sesame mutant lines changed from level moderate to small in number

**Table 5.** The comparison genetic parameter of $M_4$ and $M_5$ generations on sesame yield components.

| Characteristics | $\sigma^2_g$ | $\sigma^2_p$ | GCV (%) | PCV (%) | H (%) | $r_g$ | $r_p$ |
|---|---|---|---|---|---|---|---|
| Plant height (cm) | ↓ | ↓ | ↓ | - | - | - | ↑ |
| Number of primary branches | - | - | - | ↑ | ↓ | ↑ | ↑ |
| Number of secondary branches | ↓ | ↓ | - | ↓ | ↓ | ↑ | ↑ |
| Number of nodes/plant | - | - | - | ↑ | ↓ | - | ↑ |
| Number of nodes to first flower | ↓ | ↓ | ↓ | ↓ | - | ↓ | ↓ |
| Stem height from base to first branch (cm) | - | - | - | - | ↓ | ↓ | ↓ |
| Stem height from base to first capsule (cm) | - | - | ↓ | ↓ | - | - | - |
| Number of capsules/plant | ↓ | ↓ | - | - | ↓ | - | ↑ |
| Biomass yield/plant (g) | - | - | - | - | ↓ | - | ↑ |
| 1000-seed weight (g) | ↓ | ↓ | - | - | ↓ | ↑ | ↑ |
| Seed yield/plant (g) | ↓ | ↓ | - | - | ↓ | - | - |

↓ (Decreased) = Associated with this trait, the significant decrease value, ↑ **(**Increased) = Associated with this trait, the significant increase value, $\sigma^2_g$=genotypic variance, $\sigma^2_p$ = phenotypic variance, GCV = genotypic coefficient of variation, PCV = phenotypic coefficient of variation, H = broad sense heritability, $r_g$ = genotypic correlation coefficient, $r_p$ = phenotypic correlation coefficient.

of primary branches, number of secondary branches, number of nodes/plant, stem height from base to first branch, number of capsules/plant, biomass yield/plant, 1000-seed weight, seed yield/plant and changed from level high to small in number of nodes to first flower.

Selection based plant height and number of capsules per plant can significantly increase genotypic and phenotypic correlation coefficients among the traits in $M_4$ and $M_5$ generations of sesame mutant lines in number of primary branches, number of secondary branches, number of nodes to the first flower and 1000-seed weight. These correlation coefficients measured the strength of the linear relationship between the variables.

## CONCLUSION

Selection based on plant height and number of capsules per plant can significantly decrease the genetic variability of seed yield and yield components in $M_4$ and $M_5$ generations of sesame mutant lines. The genotypic and phenotypic correlation coefficients significantly increase between seed yield and plant height, number of primary branches, number of secondary branches, number of nodes/plant, number of capsules/plant, and 1000-seed weight after selection.

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## REFERENCES

Akbar F, Rabbani MA, Shinwari ZK, Khan SH (2011). Genetic divergence in sesame (*Sesamum Indicum* L.) landraces based on qualitative and quantitative traits. *Pak. J. Bot.* 43(6):2737-2744.

Aristya VE, Taryono (2016). Factor wise contribution on sesame seed yield. *AIP Conference Proceedings* 1755, 040007. The AIP Publishing.

Begum T, Dasgupta T (2014). Induced genetic variability, heritability, and genetic advance in sesame (*Sesamum indicum* L.). *SABRAO J. Breed. Genet.*46 (1): 21-33.

Biabani AR, Pakniyat H (2008). Evaluation of seed yield related characters in sesame (*Sesamum indicum* L.). *Pak. J. Biol. Sci*. 11: 1157-1160.

Draper NR, Smith H (1998). *Applied Regression Analysis 3rd Ed*. John Wiley and Sons, Inc. New York. pp. 706.

Falconer DS (1960). *Introduction to Quantitative Genetics 2nd Ed*. Longman Inc., New York. pp. 457.

Firmansyah, Taryono, Yudono P (2012). The dynamics of sesame (*Sesamum indicum* L.) growth type. Ilmu Pertanian *(Agri. Sci.)* 15 (2): 30-46.

Furat S, Uzun B (2010). The use of agro-morphological characters for the assessment of genetic diversity in sesame (*Sesamum indicum* L.). *Plant Omics J.* 3(3): 85-91.

IPGRI, NBPGR (2004). *Descriptors for Sesame* (*Sesamum* spp.). International Plant Genetic Resources Institute, Rome; and National Bureau of Plant Genetic Resources, New Delhi. pp.64.

Johnson HW, Robinson HF, Comstock RE (1955). Estimation of genetic and environmental variability in soybean. *Agron. J.* 47: 314-318.

Johnson LA, Suleiman TM, Lusas EW (1979). Sesame protein, a review and prospectus. *J. Am. Oil Chem. Soc.* 56(3):463-468.

Kearsey MJ, Pooni HS (1996). *The Genetical Analysis of Quantitative Traits 1st Ed*. Springer-science+business media, B.V. Bristol, pp. 381.

Khan NU, Marwat KB, Hassan G, Farhatullah, Batool S, Makhdoom K, Ahmad W, Khan HU (2010). Genetic variation and heritability for cotton seed, fiber and oil traits in *Gossypium hirsutum* L. *Pak. J. Bot.* 42(1): 615-625.

Knight R (1979). *Quantitative Genetics Statistics and Plant Breeding*. Brisbane. pp. 41-78.

Laurentin HE, Karlovsky P (2006). Genetic relationship and diversity in a sesame (*Sesamum indicum* L.) germplasm collection using amplified fragment length polymorphism (AFLP). *BMC Genet.* 7: 1-10.

Littell RC, Milliken GA, Stroup WW, Wolfinger RD, Schabenberber O (2006). *SAS for Mixed Models 2nd Ed*. SAS Institute, North Carolina. pp. 814.

Parameshwarappa SG, Palakshappa MG, Salimath PM, Parameshwarappa KG (2009). Studies on genetic variability and character association in germplasm collection of sesame (*Sesamum indicum* L.). *Karnataka J. Agri. Sci*. 22 (2): 252-254.

Rajput MA, Khan ZH, Jafri KA, Ali JAF (2001). Genetic improvement of *Sesamum indicum* through induced mutations. Sesame Improvement by Induced Mutations. International Atomic Energy Agency. Vienna. Austria. pp. 85-98.

Scossiroli RE (1977). Mutations in characters with continuous variation. *Manual on Mutation Breeding*. (Tech. Rep. Serial No. 19). IAEA, Vienna, pp. 118-123.

Singh RK, Chaudhary BD (1977). *Biometrical Methods in Quantitative Genetics Analysis*. Kalyani Publishers. Indiana New Delhi. pp. 304.

Steel R, Torrie J (1980). *Principles and Procedures of Statistics a Biometrical Approach 2nd Ed*. Mc Graw-Hill, Inc, New York. pp. 471-472.

Suja KP, Jayalekshmy A, Arumughan C (2004). Free radical scavenging behavior of antioxidant compounds of sesame (*Sesamum indicum* L.) in DPPH system. *J. Agri. Food Chem.* 52: 912-915.

Usharani KS, Kumar CRA (2016). Estimation of variability, heritability and genetic advance in Mutant populations of black gram (*Vigna mungo* L. Hepper). *SABRAO J. Breed. Genet.* 48 (3): 258-265.

Uzun B, Yol E, Furat S (2013). Genetic advance, heritability and inheritance in determinate growth habit of sesame. *Aust. J. Crop Sci.*, 7: 978-983.

Weiss EA (1971). *Castor, Sesame and Safflower*. Leonard Hill, London. pp. 311-525.

Wirnas D, Widodo I, Sobir, Trikoesoemaningtyas, Sopandie D (2006). Selection of agronomic characters to construct selection index on 11 soybean populations F6 generation. *Bul. Agron.* 34 (1): 19 – 24.

Yol E, Karaman E, Furat S, Uzun B (2010). Assessment of selection criteria in sesame by using correlation coefficients, path and factor analyses. *Aust. J. Crop Sci.* 4 (8): 598-602.

Yol E, Uzun B (2012). Geographical patterns of sesame (*Sesamum indicum* L.) accessions grown under Mediterranean environmental conditions, of a core collection. *Crop Sci*. 52: 2206−2214.