Genetic variability parameters of maize (*Zea mays* L.) mutant irradiated gamma-ray

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Abstract. Mutation induction often used to increase genetic variability in plant breeding for further proceed. Thirty inbred lines of maize mutants (*M*$_1$) of were evaluated in a randomized complete block design experiment with three replications for morphology and agronomy of genetic variability parameters. Data were collected on days to anthesis and silking, anthesis-silking interval (ASI), plant height, leaves number, days to maturity, ear number, grain yield, grains number, weight of 100-grain. Mean values were used to determine characters' phenotypic and genotypic variances, phenotypic, genotypic and environmental coefficients of variation. Moderate heritability estimates were observed for most traits. Otherwise based on genotypic coefficient of variance, for most traits had low genetic variability but generally high genetic variability was observed for most traits based on standard deviation of genotypic variance. Grain yield as important trait had moderate genetic variability based on heritability estimates, high based on genotypic coefficient of variance and standard deviation of genotypic variance. Hence provides better opportunities for selecting plant material regarding these traits.

1. Introduction

Maize is important and strategic cereal crop in Indonesia has role not only as food security but also national engine of economy because it provides food, feed and raw materials for industries such as bioethanol and cosmetics. This crop is widely cultivated in the world in almost 178 million ha and contributes to 50% (1,170 MN M T) in the total grain production of the world [1].

Integrated management strategy of maize cropping system for higher yield, involve improvement of cultivation practice and superior varieties for specific location tolerance to biotic and abiotic stress. Despite the volume of improvement research and extensive heterosis exploitation in maize, but it is still needed a continuous and consistent selection for higher grain yield.

To develop superior varieties require high genetic variability so as greater the opportunity to get the traits intended. Increasing variation in basic population can be obtained by mutation induction physically gamma ray [2].

Information of genetic variability is important for selection so as the higher genetic variability the more effective of selection. Genetic variability for agronomic characters therefore is a key component of breeding programs for broadening the gene pool of crops [3]. A number of techniques are available for the extent of variability in plant population. Heritability is a measure of the phenotypic variance attributable to genetic causes and has predictive function in plant breeding [4]. Heritability assumes that individuals more closely related are more likely to resemble one another than distant ones. The present study was conducted to determine genetic variability components and heritability estimates of maize mutant inbred lines.
2. Material and Methods

2.1. Material and Methods

The progeny (F₁) of maize origin from open pollinated cultivar had been irradiated with gamma rays (Cobalt 60) were inbred lines (M₁) cultivated in randomized block design and replicated three times at experimental field.

Seed were sown in two-row plot with a spacing of 0.75 m between and 0.25 within the hill and two seeds per hill. Seedlings were later thinned to one plant per stand two weeks after sowing (WAS). Weeding manually was done at two WAS and fourth WAS. Fertilizer (NPK 10:10:10) was applied 333 kg/ha before sowing, and nitrogen fertilizer at a rate of 180 kg N/ha in two split application at 10 and 30 days after sowing (DAS). The inbred lines were harvested manually and individually at harvest maturity.

The measured traits included plant height, leaves number, days to anthesis, days to silking, anthesis-silking interval (ASI), ear number, days to maturity, 100-grain weight, grains number per ear and grain yield per plant.

2.2. Statistical Analysis

The data was collected was subjected to analysis of variance (ANOVA) using program MS Excel package. High broad-sense heritability estimates and variance components (genotypic and phenotypic components) were calculated from the ANOVA by using the following formula [5]:

\[
\text{Genotypic variance (}\delta^2_g) = \frac{\text{GMS} - \text{EMS}}{\text{GMS}}
\]

\[
\text{Phenotypic variance (}\delta^2_p) = \delta^2_g + \delta^2_e
\]

\[
\text{Environmental variance (}\delta^2_e) = \text{EMS}
\]

\[
H^2 = \frac{\delta^2_g}{\delta^2_p} \times 100%
\]

\[
H^2 = \text{Broad sense heritability for a trait.}
\]

Heritability estimates were grouped high (>50%), moderate (20-50%) and low (<20%) as proposed by [6].

Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) were computed according to the formula suggested by [7]:

\[
\text{GCV} = \frac{\delta^2_g}{\bar{x}} \times 100%
\]

\[
\text{PCV} = \frac{\delta^2_p}{\bar{x}} \times 100%
\]

PCV and GCV values as low (0-10%), moderate (10 - 20%) and high (>20%) [8].

Standard deviation of genotypic variance was formulated according to Anderson and Brancoff (1952), cited [9] as following:

\[
\delta^2_g = \sqrt{\frac{2}{d_f+2} \left( \frac{GMS^2}{d_f} + \frac{EMS^2}{d_f+2} \right)}
\]

If \(\delta^2_g > 2 \delta^2_g\) shows high genetic variability but if \(\delta^2_g < 2 \delta^2_g\) shows low genetic variability.

3. Results and Discussion

Mean squares from the analysis of variance for the ten traits are shown in Table 1. Significant effect of replication were observed in plant height, leaf number, days to anthesis and days to silking. The inbred lines of maize mutan (M₁) also had significant effect for almost of traits except ear number per plant. It revealed that significant differences were observed among lines in respect of traits were studied. This gives an ample opportunity for plant breeders to improve these traits through selection. Similarly,
other researcher [10] reported highly significant differences among maize inbred lines for plant height, leaves number, days to anthesis, days to silking, ASI, grains yield, ear number and ear weight.

Table 1. Mean square from analysis of variance for traits of inbred lines from three of variety

| S.V.          | df  | PH          | LN  | A    | S    | ASI | M    | EN   | GY   | GN   | 100-G |
|---------------|-----|-------------|-----|------|------|-----|------|------|------|------|-------|
| Replication   | 2   | 5021**      | -   | 7.20 | *    | 35.08* | 0.36 | 7.50 | 0.013 | 952.2 | 2420 | 0.44  |
| Treatment     | 9   | 1011**      | 3.25 | 17.63* | 15.38* | 9.36  | 0.096 | 1092.1* | 21037*  | 27.12** | 9     |
| Error         | 18  | 415         | 10.48 | 10.27 | *    | 7.15* | *    | 0.089 | 707.6 | 1300  | 15.98  |

Table 2. Mean and range performance of traits of maize mutant inbred lines (M1)

| Traits                          | Mean  | Range  |
|---------------------------------|-------|--------|
| Plant height (cm)               | 211.0 | 161.7-246.7 |
| Leaves number                   | 14.19 | 11.3-16.7 |
| Days to anthesis                | 49.63 | 40.7-53   |
| Days to silking                 | 53.82 | 49-60     |
| Anthesis-silking interval       | 4.17  | 0.7-8.0   |
| Days to maturity                | 73.14 | 69-73.6   |
| Ear number per plant            | 1.1   | 1.0-1.7   |
| Grain yield per plant (g)       | 75.39 | 30.0-131.0|
| Grains number per ear (g)       | 313.2 | 131.7-513.2|
| Weight of 100-grains (g)        | 24.31 | 14.7-31.3 |

Mean and range performance of traits were presented in Table 2. Mean of plant height and grain yield per plant of inbred lines (M1) were very varied among other traits, ranged between 161.7-246.7 (cm) and 30.0-131.0 (g) respectively. Days to anthesis and silking of inbred lines (M1) were earlier (about 5 days) than their parent. Line number 73 had the highest of grain yield per plant 131 gram. Earlier days to maturity was obtained by line number 27. A number of studies of effect gamma irradiation on plant can change important traits such as yield, dwarfism, early maturity, resistance of diseases [11]. Gamma rays have proved to be more economical and effective compared to other ionizing radiations because of their easy availability and power of penetration [12]. When lack of genetic variation, mutagenic agents such as radiations and certain chemicals can be used to induce mutations and generate genetic variation from which desired mutants can be selected [13].

Genetic variability parameters were presented in Table 3. Grain yield had moderate variability criteria based on broad heritability estimate, genotypic coefficient of variation and high variability based on standard deviation of genotypic variance for inbred lines of maize mutant (M1). Other research recorded moderate heritability estimates for yield in two seasons [4]. It is also reported higher and relatively moderate broad-sense heritability of the traits were detected [14], while [10] observed high heritability estimates for all the traits they studied. Heritability assumes that individuals more closely related are more likely to resemble one another than distant ones [15]. The higher genetic variability is the more effective for selection activity. The heritability estimates is important in choosing the suitable segregating generations for exhibiting the best expression of gene of different studied traits [16]. Heritability estimate assists breeders to allocate resources necessary to effectively select for desired traits and to achieve maximum genetic gain with little time and resources [10].
Some inbred lines had high grain yield with earlier days to maturity than genotypic coefficient of variation, despite had low genetic variability for most traits, it reveals selection to be more effective due to less environmental influence. Hence it provides better opportunities for selecting plant material regarding these traits. This revealed that variations were transmitted to the progeny and indicated potential for developing high yielding varieties through selection of desirable plants in succeeding generations [14]. Otherwise if genetic variability is low, the selection would be less effective due to high environmental influence.

### Days to maturity also moderate variability based on broad sense heritability estimate for inbred lines (\(H^2\)) and high variability based on standard deviation of genotypic variation, despite had low variability based on genotypic coefficient of variation. Phenotypic coefficient of variation was higher than genotypic coefficient of variation. Other researcher also observed higher phenotypic coefficient of variation than genotypic coefficient of variation for wheat plant [17]. Moderate heritability estimates were observed for most traits, whereas generally high genetic variability was observed for most traits based on standard deviation of genotypic variance. Hence it provides better opportunities for selecting plant material regarding these traits. This revealed that variations were transmitted to the progeny and indicated potential for developing high yielding varieties through selection of desirable plants in succeeding generations [14]. Otherwise if genetic variability is low, the selection would be less effective due to high environmental influence.

### 4. Conclusion

Maize inbred lines had high genetic variability for most traits, it reveals selection to be more effective due to less environmental influence. Some inbred lines had high grain yield with earlier days to maturity can be as such superior lines candidates.

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