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Morphological characteristics and yield performance of mutant soybean [*Glycine max* (L.) Merr.] M_6 genotypes in Jatinangor, Sumedang, West Java

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ABSTRACT

Current breeding efforts in soybean largely focus on identifying genotypes with high seed yield and large seed size. Our study applied a mutation using 250 Gy Gamma-Ray Irradiation to soybean cv. Anjasari. The variability in the M1 generation was identified, and the planting was continued to M2 M3, M4, M5 until M6 generation. The objectives of this research were to evaluate mutant lines exhibiting a good performance in yield and morphological characteristics that can support the yield component in M6 generation. This research was conducted from January 2019 to May 2019 at Ciparanje Experiment Station, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, West Java. The experiment was arranged in a Randomized Completely Block Design with fifteen mutant soybean genotypes as treatments with two replications within each treatment. The results showed several genotypes produced higher yield and better agro-morphological characteristics. The genotypes MR-33, MR-4A, and MR-2A showed significantly higher number of total pods per plant. Meanwhile, the genotypes MR-35A, MR-37, MR-23, MR-36A, MR-3A, MR-29A, MR-34A, MR-4A, MR-17, and MR-5A showed a higher value in weight of 100 seeds. The highest yield was observed in MR-29A and MR-23, which then will be used as the genotypes for multilocation test for stability.

INTRODUCTION

Soybean is an important annual food crop after rice and corn due to its high protein content, ranging between 40% to 49% (Sudaryanto and Swastika, 2007; Banaszkiewicz, 2012). Soybean, as a food ingredient, has fairly high and balanced nutrition because it contains protein, unsaturated fatty acids, carbohydrates, minerals, vitamins, phenolic compounds, lecithin, and iso-flavonoid content (O'Keefe et al., 2015). Therefore, awareness of the importance of consuming soybean that has a balanced nutritional content as the main food source has increased from year to year.

The increase in soybean needs is not offset by an increase in domestic soybean production. Soybean imports in Indonesia continue to increase from 2010–2017. Badan Pusat Statistik (2018) records an increase in soybean imports from 2010–2017. In 2017, soybean imports reached 2.67 million ton with an increase of 18.1 % of the total imports of the previous year, while the export volume was only around 29.64 thousand ton. Therefore, it is indicates there are low community preference for local soybeans.

One of the factors causing people to have a low preference for local soybeans is the low productivity of local soybeans, and most of the soybean cultivars in Indonesia have a small seed. Indonesian soybean productivity in 2017 was around 1.52 $ton.ha^{-1}$. The potential for Indonesian soybean productivity is still below the average soybean productivity of other countries in 2017, such as Thailand (1.57 $ton.ha^{-1}$), Brazil (3.23 $ton.ha^{-1}$), and Argentina (3.27

ton.ha^{-1}) (United States Department of Agriculture, 2019).

Mutation is either one way to induce variations in the context of plant breeding in soybean germplasm, especially in large seed characters and high yield. Based on the utilization of gamma radiation in vivo and in vitro, followed by their utilization in breeding programs, induced mutation is one of the secure ways to improve genetic diversity in many plants including in soybean (Yuliasti and Reflinur, 2017). The latest data showed more than 2600 mutant varieties with desirable quantitative and qualitative traits have been introduced. Laskar and Khan (2017) obtained favorite traits using physical mutagens in lentils and advocated the importance of induced mutations as one of the most effective and efficient approaches to regenerate and restore the genetic variability in lentils. Mutation breeding is probably an effective tool for generating variability in the existing varieties and selecting lines with desirable characters, which proved to be an ideal crop.

In this study, the mutation carried out was by using a 250 Gy Gamma-Ray Irradiation to soybean cv. Arjasari. Irradiation was performed using Gamma cell 200 machine owned by the National Nuclear Energy Agency (BATAN). The variability in the M1 generation was identified, and the planting was continued to M2 M3, M4, and M5 generation. In M5 generation planted from September 2019 to December 2019, it was found that genotypes MR-35A, MR-37, MR-23, MR-36A, MR-22A, MR-33, MR-16A, MR-3A, MR-29A, MR-34A, MR-4A, MR-17, MR-2A, MR-5A, and MR-8A showed a higher performance in yield and yield component compared to Arjasari cultivar as a wild type. Our present study was conducted to obtain promising genotypes of mutant soybean in M6 generation showing high yield and better morphological characteristics as a yield component. The genotypes of M6 generation that have been selected in this study will be used as prospective genotypes for multilocation test for stability of high yield in the next generation.

MATERIALS AND METHODS

This research was conducted from January 2019 to May 2019 at Ciparanje Experiment Station, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, West Java at an altitude of 850 meters above sea level. The soil type of the research site is Ultisol. Fifteen mutant soybean genotypes were used as the materials in this experiment. Others materials used were cow manure, Urea fertilizers, KCl fertilizers, SP-36 fertilizers, fungicides (Karbofuran 3G), insecticides (deltametrin), water, and liquid organic fertilizer. This experiment was arranged in a Randomized Complete Block Design (RCBD) consisting of 15 genotypes as treatments with two replications within each treatment.

Urea, KCl, and SP-36 fertilization was performed once in February and April, which was applied by making a patch on the side of the seeds planted in the field. The liquid organic fertilizer volume for each plot (1.2 m^2) was 7.5 mL per plant, and it was applied every two weeks until the harvest period. Plant spacing for each plot was 15 cm ×40 cm. The variables observed in this study included plant height, total number of pods per plant, total number of seeds per plant, total number of branches per plant, and yield. The data were analyzed using the analysis of variance (ANOVA) and the Scott-Knott test at a level of α = 5%, performed in R studio 1.1.463 (Jelihovschi et al., 2014) .

RESULTS AND DISCUSSIONS

Plant height and number of branches per plant

Plant height is the parameter of plant growth frequently observed since it becomes the determinant for the yield quality, and it can be simply measured (Zhang et al., 2018). Xue et al. (2019) find that plant height is an essential trait in soybean, as taller plants may have higher yields but may also be at risk for lodging. In this study, there was no significant difference in the plant height based on the Scott-Knott test results (Table 1).

Total number of branches is the characteristic that has indirect effect on the seed yield (Faot et al., 2019). The various mutant soybean genotypes compared in this study showed significantly different number of branches based on the Scott-Knott test (Table 1). Genotypes MR-22A, MR-34A, MR-4A, MR-2A, MR-5A, and MR-8A showed higher plant height compared to others. The number of branches generally have a strong positive correlation with the number of seeds and yield (Vu et al., 2019). It is because the increasing number of branches indicates an increasing number of pods per plant (Egli, 2013).

Table 1. Plant height and number of branches of 15 mutant soybean genotypes at harvesting in Ciparanje, Sumedang, West Java

Genotypes	Plant height (cm)	Number of branches per plant
MR-35A	48.50 a	3.5 a
MR-37	60.00 a	3.0 b
MR-23	57.00 a	3.5 b
MR-36A	59.00 a	3.0 b
MR-22A	52.50 a	5.0 a
MR-33	55.50 a	3.5 b
MR-16A	59.00 a	2.0 b
MR-3A	57.00 a	3.5 b
MR-29A	55.00 a	2.0 b
MR-34A	55.50 a	4.5 a
MR-4A	59.00 a	5.0 a
MR-17	52.50 a	2.5 b
MR-2A	68.50 a	5.0 a
MR-5A	67.50 a	4.5 a
MR-8A	58.75 a	4.5 a
Mean	57.67	3.67
CV (%)	5.05	17.67

Remarks: Means followed by the same letters in the same column were not significantly different based on Scott-Knott test at α= 5%.

Table 2. Number of pods per plant and number seeds per plant of 15 mutant soybean genotypes at harvesting in Ciparanje, Sumedang, West Java

Genotypes	Number of pods per plant	Number of seeds per pod
MR-35A	44.00 c	1.94 a
MR-37	58.00 b	1.62 a
MR-23	48.50 c	1.93 a
MR-36A	34.00 d	1.61 a
MR-22A	41.00 c	1.51 a
MR-33	79.00 a	2.09 a
MR-16A	47.00 c	2.35 a
MR-3A	48.50 c	2.06 a
MR-29A	40.00 c	2.08 a
MR-34A	52.50 b	2.16 a
MR-4A	73.00 a	1.11 a
MR-17	20.00 d	1.63 a
MR-2A	61.00 a	1.71 a
MR-5A	57.00 b	1.92 a
MR-8A	31.00 d	2.05 a
Mean	49.97	1.85
CV (%)	11.08	21.3

Remarks: Means followed by the same letters in the same column were not significantly different based on Scott-Knott test at α= 5%.

Table 3. Weight of one hundred seeds and Yield of 15 mutant soybean genotypes at harvesting in Ciparanje, Sumedang, West Java.

Genotypes	The weight of 100 seeds per 100 SW (g)	Yield (g.plot^{-1})
MR-35A	21.38 a	81.54 e
MR-37	21.09 a	6.02 f
MR-23	20.51 a	299.24 b
MR-36A	19.96 a	102.76 e
MR-22A	18.20 b	299.90 b
MR-33	17.66 b	122.54 e
MR-16A	18.40 b	177.26 d
MR-3A	20.81 a	23.54 f
MR-29A	21.59 a	290.95 b
MR-34A	21.03 a	54.78 f
MR-4A	19.77 a	313.16 b
MR-17	20.15 a	212.14 c
MR-2A	18.58 b	443.58 a
MR-5A	19.14 a	83.73 e
MR-8A	14.19 c	115.84 e
Mean	19.5	175.13
CV (%)	3.42	5.89

Remarks: Means followed by the same letters in the same column were not significantly different based on Scott-Knott test at α= 5%.

Number of pods per plant and number of seeds per pod

The number of branches per plant, total number seeds per pod, and the number of pods per plant are three main characteristics that have a very large direct effect on yields of soybean both in segregated populations and in homozygous populations (Madanzi et al., 2012). Based on Scott-Knott test, the various mutant soybean genotypes compared in this study showed significantly different number of pods per plant (Table 2). Genotypes MR-33, MR-4A, and MR-2A produced higher number of pods per plant.

The number of seeds per pod in various genotypes showed insignificant different results compared to control (Table 2). The number of seeds per pod does not have a correlation with the number of pod per plant, so that the number of seeds per pod does not correlate with yield. Thus, the number of seeds per pod that does not show a significant difference will not correlate with the weight of 100 seeds and yield (Alan and Geren, 2007; Oz et al., 2009).

The weight of 100 seeds (100 SW) and yield

The weight of 100 seeds (100 SW) is one of the most important traits that control soybean yield (Liu et al., 2018). The weight of 100 seeds (100 SW) is one of the essential parameters affecting the soybean performance and productivity In Indonesia (Alan and Geren, 2007; Ali et al., 2018). Yield, also known as agricultural productivity, is the measurement of the ratio of agricultural outputs to agricultural inputs (Dharmasiri, 2012). The grain yield of soybean is a function of cumulative effect of various yield components, which are influenced by genetic makeup of the variety, various agronomic practices, and environmental conditions (Hu and Wiatrak, 2012). The weight of 100 seeds is classified into three categories, namely small (<10 g per 100 seeds), medium (10g to 14 g per 100 seeds), and large (>14 g per 100 seeds) (Krisnawati and Adie, 2015).

The various genotypes compared in this study showed significantly different weight of one hundred seeds (Table 3). Genotypes MR-35A, MR-37, MR-23, MR-36A, MR-3A, MR-29A MR-34A, MR-4A, MR-17, and MR-5A produced the higher value in weight of 100 seeds. The weight of one hundred seeds is positively correlated with the yield, so that the genotypes that have higher value in the weight of 100 seeds have higher yield (Burris et al., 1973). Yield is an important component in agriculture because crop production depends on yield as one of the main parameters. The yield was obtained from data per clump converted to a population per plots (5 m^2) of soybean plants, assuming a spacing of 15×40 cm. The results showed that the genotypes MR-2A, MR-4A, MR-29A, MR-23, and MR-22A had higher yield compared to other genotypes.

CONCLUSIONS

The results in this study showed that several genotypes had higher yield and better morphological characteristics, such as yield component. Genotypes MR-33, MR-4A, and MR-2A showed the higher number of pods per plant. Genotypes MR-35A, MR-37, MR-23, MR-36A, MR-3A, MR-29A MR-34A, MR-4A, MR-17, and MR-5A showed the higher value in weight of 100 seeds. Meanwhile, genotypes MR-2A, MR-4A, MR-29A, MR-23, and MR-22A produced the higher yield. The genotypes MR-29A and MR-23 are the genotypes that have a potential to be used in stability test in the next generation to evaluate the stability in yield performance in multilocation under different season.

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