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Genetic diversity and heritability of seed characters of soybean genotypes (*Glycine max* (L.) Merr.) F3 generation in rainy season planting

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ABSTRACT

Introduction: Soybeans an important source of vegetable protein. Soybean production in Indonesia is still low and needs to be increased. One strategy is to increase the frequency of planting during the rainy season. Soybean development during the rainy season requires information on genetic diversity and heritability. The purpose of this study was to analyze the genetic diversity and heritability of F3 generation soybean lines planted during the rainy season. **Methods:** The experiment was used randomized block design (RBD). The Least Significant Increase (LSI) test at the 5% level is used to see the difference in appearance of the test line with the check variety. Genetic parameters was analyzed by estimating genetic and phenotypic variance, and heritability. **Results:** The results showed that genotype UM002 differed significantly from the check cultivar in seed number per plant, and 100-seed weight showed wide genetic variability with high heritability. Seed length, width, and thickness also showed wide genetic variability with moderate heritability. In contrast, seed yield per plant showed low heritability and narrow genetic variability, suggesting a more substantial environmental influence. **Conclusion:** UM002 line showed better seed number performance per plant compared to two check varieties, Deja 2 and Detam 4, which can be used as a promising soybean line that is adaptive to the rainy season. The 100-grain weight character showed a high heritability value. This indicates that the 100-grain weight character can be used as a selection criterion for soybeans during the rainy season in an effort to increase selection effectiveness.

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INTRODUCTION

Soybeans (*Glycine max* (L.) Merr.) are a functional food source with high nutritional value. Soybean seeds contain 40-43% protein (Kholmurodova et al., 2023). In Indonesia, soybeans account for 90% of the food industry, and demand for soybeans as industrial raw materials increases annually by around 2.8 million tons (Indonesian Legumes and Tuber Crops Research Institute, 2020). Soybean production in Indonesia in 2022 was 202,472 tons, while soybean imports totaled 2,702,848 tons, indicating that around 92.5% of the national soybean supply came from imports (Dyah, 2020). Low soybean production is partly due to a decline in planting area, which affects national soybean productivity.

The strategy to increase soybean production involves increasing planting frequency. Soybeans can be planted during the rainy season (off-season), but land use during this period is still limited, as high rainfall can cause plants to experience excess water stress. This condition is caused by the rainy season's high rainfall, low temperatures, and high humidity (Sukmasari et al., 2022). Efforts to anticipate rainy-season conditions include using adaptive cultivars. Wijaya et al. (2024) emphasize the importance of using water-stress-tolerant cultivars to ensure soybean planting remains productive even under suboptimal environmental conditions.

The availability of cultivars for planting during the rainy season is still limited. This limitation makes it difficult to select cultivars that are adaptive for planting during the rainy season. The complex nature of cultivar resistance during the rainy season is one reason why the development of superior cultivars has not been optimal. Li et al. (2024) reported that stress experienced by soybeans during high rainfall conditions is not only due to excess water in the soil but also complex factors such as low light intensity, nutrient balance in the soil, and the development of pests and diseases. Skidmore & Coppess, (2023) reported that nutrient imbalance during the rainy season occurs due to runoff and sedimentation caused by rainwater. These problems result in very low yields for soybeans planted during the rainy season. The availability of plant genotypes obtained from plant breeding programs is a solution to developing plant characteristics that are adaptive to specific land and environmental conditions. According to Wijaya et al. (2022) Breeding lines have one or more specific advantages, such as high yield potential, tolerance to growing environments, good product quality, and tolerance to pests and diseases. These superior traits must be accompanied by extensive genetic information to determine genetic diversity (Malani et al., 2024).

Understanding the genotypic response of soybean plants in each generation during the rainy season is important for assessing genetic parameters and adaptation to the growing environment. Genetic parameters are a crucial component of plant breeding, supporting selection. This genetic information helps breeders obtain genotypes that consistently perform well across all locations or perform well only in specific locations (Sari et al., 2013). Genetic diversity comprises genotypic, phenotypic, and environmental variation (Apriliyanti et al., 2016).

Population formation for resistance to rainy season planting is carried out to adapt potential lines and increase the frequency of resistance genes to rainy season conditions. The lines tested are the result of crosses originating from parents indicated to have resistance genes in the rainy season. Research results from Yofa et al. (2021) reported that the Anjasmoro and Wilis cultivar showed the highest seed weight performance per plot during rainy season planting. Nani et al. (2020) reported that the Dena 1 cultivar showed the highest productivity during rainy season planting. Chae et al. (2025) reported that differences in productivity in each environment can be influenced by environmental conditions and genetic interactions with the environment, therefore it is necessary to pay attention to the suitability of the growing environment to increase plant productivity. Gowdra et al. (2025) reported that yield reductions obtained during rainy season soybean planting reached 47 to 68.2% compared to planting under optimal conditions.

The quality of a plant can be influenced by its genotype, where each plant has a different genotype. This difference will eventually become genetic diversity within a plant, which is one of the factors influencing plant breeding efforts. Extensive genetic diversity greatly determines the genetic diversity of its offspring. Variation in genotypic values among individuals within a population indicates genetic diversity. The higher the genetic diversity in a population, the greater the likelihood that an organism will acquire traits. Adie, M & Krisnawati, (2019) reported that each soybean genotype responds differently to the same or different environmental conditions. According to Susanto and Nugrahaeni (2018), superior cultivars exhibit diverse characteristics, including yield potential, maturity age, seed size, seed quality, resistance to biotic and abiotic stresses, and adaptation to different growing environments.

To support successful plant breeding, information on genetic parameters is required. Genetic parameters include genetic variation, phenotypic variation, and heritability, which describe the extent of trait differences due to genetic factors relative to environmental influences (Napier et al., 2023). Heritability values are the proportion of genetic variation to total phenotypic variation and are used to determine the extent to which a trait is heritable. Characters with high heritability are generally easier to select because genetic factors have a greater influence, whereas low heritability indicates that environmental factors are more dominant (Wijaya et al., 2024). Thus, information on genetic parameters and heritability is important as a basis for selection and for determining appropriate breeding strategies.

Seed characteristics, such as length, width, thickness, seed weight per plant, and 100-grain weight, are important determinants of soybean yield and quality. Recent research shows that several seed traits have broad genetic diversity and moderate to high heritability, making them potentially useful as a basis for selection in breeding programs (Suseno Amien et al., 2021). Even under water-stressed conditions such as the rainy season, some seed traits still show significant genetic influence (Wijaya & Wahyuni, 2025). This underscores the importance of studying the genetic parameters of seed traits during the rainy season as a first step toward developing superior, adaptive soybean genotypes.

The availability of promising strains that are adaptive to rainy season conditions is essential for developing plant varieties. The first step in identifying adaptation to rainy season conditions can be done by analyzing genetic parameters. This study aimed to examine the genetic parameters of seed characters and to assess the performance of 27 F3 soybean genotypes in the rainy season, thereby providing basic information to support a breeding program for superior soybeans adapted to humid environmental conditions. This needs to be done in the development of soybean varieties to increase national soybean production.

METHODS

Time and site experiment

This experiment was conducted on the Techno Park land of the Faculty of Agriculture, Majalengka University, located in Babakan Jawa sub-district, Majalengka district, Majalengka regency, at an altitude of 146 meters above sea level from December 2023 to March 2024.

Material and genetic material

The materials used in this study included seeds from 25 crossbred genotypes (the result of crossing parents who have large seed size and high yield potential) and two cultivars (checks, namely Deja 2 (large seeds, adaptive in various ecosystems) and Detam 4 (high yielding) (Table 1), Urea, SP36, and KCL fertilizers, insecticides, fungicides, water, and soil. The tools used in this study included hoes, measuring tape, digging, kored, mica plastic, staplers, stakes, raffia, sprayers, brown envelopes, rulers, vernier calipers, analytical scales, ovens, laptops, stationery, and cellphone cameras.

Table 1. Genotypes of soybeans resulting from cross-breeding

Genotype	
UM001 = Gepak kuning × Mutiara 3 (2)	UM014 = Mutiara 3 × Detam 2 (1)
UM002 = Gepak kuning × Detam 4 (1)	UM015 = Mutiara 3 × Detam 2 (2)
UM003 = Gepak kuning × Detam 4 (2)	UM016 = Mutiara 3 × Biosoy (1)
UM004 = Gepak kuning × Detam 4 (3)	UM017 = Mutiara 3 × Biosoy (2)
UM005 = Deja 2 × Mutiara 3 (1)	UM018 = Mutiara 3 × Biosoy (3)
UM006 = Deja 2 × Mutiara 3 (2)	UM019 = Detam 4 × Deja 2 (1)
UM007 = Deja 2 × Mutiara 3 (3)	UM020 = Detam 4 × Deja 2 (2)
UM008 = Deja 2 × Detam 2 (1)	UM021 = Detam 4 × Detam 2 (1)
UM009 = Deja 2 × Detam 2 (2)	UM022 = Detam 4 × Detam 2 (2)
UM010 = Deja 2 × Detam 2 (3)	UM023 = Detam 4 × Detam 2 (3)
UM011 = Deja 2 × Detam 1 (1)	UM024 = Detam 4 × Biosoy (1)
UM012 = Deja 2 × Detam 1 (2)	UM025 = Detam 4 × Biosoy (2)
UM013 = Mutiara 3 × Detam 4 (1)	Check 1 = Deja 2 ; Check 2 = Detam 4

UM001 to UM025 = genotypes test

Research design

The method used was a field experiment with a Randomized Block Design (RBD) and two replications. Planting was carried out in a plot measuring 1.2 m x 3 m. The planting distance used was 40 cm x 15 cm. The distance between plots was 50 cm, and the trench was 40 cm deep.

Data analysis and data collection

The data analysis used a Randomized Block Design (RBD), with the following linear model (Petersen, R, 1994):

$$y_{ij} = \mu + \tau_i + \beta_j + \epsilon_{ij}$$

Where: y_{ij} = Respons from treatmen to-$_i$ for block to-$_j$: μ = general mean; τ_i = treatments effect to – $_i$; β_j = Block effect to-$_j$; ϵ_{ij}= random error

To determine the differences in performance between the test strain and the control variety, the Least Significant Increase (LSI) test was used at the 5% level (Petersen, 1994).

$$LSI = t_\alpha \sqrt{\frac{2MSE}{r}}$$

Where: t_α = t-table value; MSE = Mean Square Error; r = replicate

The diversity components of a character, according to the Hallauler et al. (2010) procedure, include genetic, environmental, and phenotypic diversity using the formula:

Genetic variation ($\sigma_g{}^2$): $\sigma_g{}^2 = \frac{KTg-KTe}{r}$
Environmental variation ($\sigma_e{}^2$): $\sigma_e{}^2$ = KTe
Phenotypic variation ($\sigma_p{}^2$): $\sigma_p{}^2 = \sigma_g{}^2 + \sigma_e{}^2$

The extent of genetic and phenotypic diversity is determined based on the standard deviation. The standard deviation of genetic diversity and the standard deviation of phenotypic diversity can be calculated using the following equation:

$$\sigma\, \sigma^2 g = \sqrt{\frac{2}{r^2}\left\{\left[\frac{(KTg)^2}{db_{g+2}}\right] + \left[\frac{(KTe)^2}{db_{e+2}}\right]\right\}}$$

$$\sigma\, \sigma^2 p = \sqrt{\frac{2}{(r)^2}\left[\frac{KTg^2}{db_{g+2}}\right]}$$

Where: $\sigma^2_G < 2\sigma_{\sigma^2 G}$ = Narrow; $\sigma^2_G > 2\sigma_{\sigma^2 G}$ = Wide; and $\sigma^2_P < 2\sigma_{\sigma^2 P}$ = Narrow phenotypic diversity; $\sigma^2_P > 2\sigma_{\sigma^2 P}$ = Wide phenotypic diversity (Diniz & de Oliveira, 2019).

The heritability value is calculated using the following equation:

$$H^2 = \frac{\sigma g2}{\sigma p2}$$

where: H^2: broad sense heritability; $\sigma_g{}^2$: genetic variance; $\sigma_p{}^2$: phenotype variety

Heritability values range from $0 \leq H \leq 100\%$. According to Diniz & de Oliveira (2019), there are three broad classes of heritability values, namely:

a) High heritability, H value>50%
b) Medium heritability, value 20%<H≤50%
c) Low heritability, H value ≤20%

The parameters observed included plant height (cm), seed length (mm), seed width (mm), seed thickness (mm) (Samples for observing seed length, seed width, seed thickness were obtained randomly from the number of seeds per plant), number of seeds per plant, seed weight per plant (g) and weight of 100 grains (BB100) (g).

RESULTS AND DISCUSSION

Agronomic character performance analysis of F3 genotypes

The soybean seed character parameters in this study included plant height, seed length, seed width, seed thickness, number of seeds per plant, seed weight per plant, and 100-grain weight. The differences in appearance of the soybean lines compared to the two check varieties can be seen in table 2.

Table 2. Seed character appearance of 27 F3 generation soybean genotypes in the rainy season

Genotype	Plant Height	Seed Length	Seed Width	Seed Thickness	Number of seeds per plant	Seed Weight per Plant	BB100
UM001	51.15	6.30	5.15	4.20	281.00	21.20	9.90
UM002	43.17	6.25	5.00	4.15	440.00 ab	32.00	8.75
UM003	31.28	5.50	4.50	3.90	162.00	11.90	6.00
UM004	37.35	6.10	4.90	4.05	227.00	17.65	8.50
UM005	53.20	8.15	5.85	4.65	243.00	29.30	15.70
UM006	53.80	7.60	5.85	4.65	217.00	28.10	14.90
UM007	29.28	7.50	5.95	4.70	83.00	7.00	10.60
UM008	41.70	6.70	5.25	4.20	97.50	5.60	6.30
UM009	39.18	8.05	6.05	4.80	134.00	15.50	13.80
UM010	42.60	6.90	5.70	4.55	136.00	13.95	11.55
UM011	45.73	7.65	5.80	4.60	162.00	15.85	14.20
UM012	42.62	6.50	5.40	4.20	142.00	15.95	9.95
UM013	63.95	6.70	5.40	3.75	331.00	21.85	10.20
UM014	56.53	6.35	5.40	3.95	333.00	28.05	10.35
UM015	46.83	6.80	5.30	3.95	172.00	11.90	8.50
UM016	24.60	5.55	4.55	3.70	30.00	1.75	6.70
UM017	39.48	6.20	5.10	3.80	244.00	19.75	8.65
UM018	48.82	6.75	5.45	4.15	240.00	17.45	9.20
UM019	39.10	6.75	5.20	4.55	155.00	13.70	10.15
UM020	38.30	6.30	4.85	3.60	159.00	16.30	8.30
UM021	44.38	6.70	5.40	4.55	215.00	21.75	11.80
UM022	49.22	7.20	5.40	4.45	239.00	24.35	12.80
UM023	47.85	7.05	5.60	4.55	263.50	24.00	13.50
UM024	42.62	7.95	5.65	4.50	238.00	23.65	12.90
UM025	42.73	7.75	5.55	4.50	195.00	20.70	12.50
DEJA 2	51.40	8.40	6.10	4.95	210.00	26.95	15.65
DETAM 4	54.55	7.30	5.70	4.65	237.50	28.50	13.00
Genotype	ns.	*	*	*	ns.	ns.	*
LSI (5%)	18.53	1.32	0.81	0.74	199.61	22.84	5.29
C1+LSI (a)	69.93	9.72	6.91	5.69	409.61	49.79	20.94
C2+LSI (b)	73.08	8.62	6.51	5.39	437.11	51.34	18.29

Description: ns = not significantly different, * = significantly different at the 5% LSI level.
Ab = significantly different from the check cultivar Deja 2 + Detam 4 + LSI level 5%.

Genotypes that perform better than check cultivars indicate that genetic differences play a significant role in determining a trait or plant appearance. Its genetics determines differences in the appearance of each variety's character, so genetic differences cause differences in plant phenotypes, which display distinct characteristics and properties that can be influenced by environmental conditions during growth (Maulana et al., 2023). The results of research Hapsari et al. (2021) reported that plant appearance under environment stressed influences pod and seed numbers, and that genetic factors influence this effect.

Genotype UM002 showed better performance than the check cultivars Deja 2 and Detam 4 in the character of the number of seeds per plant. The number of seeds is the main factor determining yield and can therefore describe a plant's potential yield. This is consistent with the results of this study, which show that the UM002 genotype had the highest number of seeds per plant (440,000), exceeding that of the check cultivar, suggesting that genetic factors strongly influence this difference. The UM002 genotype is a cross of Gepak Kuning x Detam 4 (1) and is classified as adaptive to humid growing environments, with high rainfall during the reproductive period. Balitkabi (2018) reported that the Gepak Kuning cultivar is adaptable to water-saturated conditions, and Detam 4 is adaptable to pod-sucking pest attacks, which affect seed yield. The number of seeds per plant is also suspected to be strongly influenced by inheritance from the female parent, namely Gepak Kuning. In line with the study by Wijaya et al. (2024), the genotypes of the crossbred offspring resemble those of the female parent. This is because the genetic factors of the Gepak Kuning cultivar produce small seeds and many branches, resulting in a high number of filled pods and seeds per plant. Wijaya & Wahyuni, (2025) reported that plants with small seed sizes produce a large number of seeds. The occurrence of differences in response to seed number characters between genotypes is thought to be due to seed yield being controlled by many genes and being very sensitive to the growing environment (Jia et al., 2025).

Estimation of genetic diversity components and heritability

Selection in supporting plant breeding will be successful if it is based on genetic parameters such as genetic diversity and heritability. The results for genetic diversity, phenotypic variance, the standard deviation of genetic and phenotypic diversity, and heritability values are shown in Table 3. Genetic diversity shows broad criteria in plant height, seed length, seed width, seed thickness, number of seeds per plant, and 100-grain weight, whereas seed weight per plant shows narrow genetic diversity. Seed characters that have broad genetic diversity indicate that the genotype population comes from a source of plant parents with different genetics, so that a plant breeding activity indicates the effectiveness of selection. This aligns with the statement by Hijrah et al. (2024) that the greater the genetic diversity in a character, the more varied its properties, in contrast to the character of 100-grain weight, which has a narrow genetic diversity. Characters that have wide genetic diversity values and wide heritability values are ideal characters to be used as selection criteria.

Table 3. Genetic parameters of soybean seed characters in the rainy season

Character	$\sigma^2 g$	$\sigma^2 p$	$2\sigma g$	$2\sigma p$	h^2	Criteria
Plant Height	33.77	115.08	13.33(w)	2.83(w)	0.29	medium
Seed Length	0.38	0.80	0.09(w)	2.85(n)	0.48	medium
Seed Width	0.10	0.25	0.03(w)	2.84(n)	0.39	medium
Seed Thickness	0.07	0.20	0.02(w)	2.84(n)	0.36	medium
Number of Seeds per Plant	2406.83	11836.90	1392.99(w)	515.76(w)	0.20	medium
Seed Weight per Plant	1.70	87.46	10.63(n)	7.49(w)	0.02	Low
Weight 100 Grains	4.96	6.81	0.73(w)	2.93(w)	0.73	high

Description: Genetic variation $\sigma^2 g > 2\sigma g$ = wide; $\sigma^2 g < 2\sigma g$ = narrow, Phenotypic variation $\sigma^2 p > 2\sigma p$ = wide; $\sigma^2 p < 2\sigma p$ = narrow, Heritability h^2 = high (>0.50), medium (0.20<h<0.50) and low (h<0.20)

Characters with narrow genetic variation are likely to be genetically heterozygous for that character, whereas wide genetic variation makes it possible that the character's loci are genetically homozygous (Meydina et al., 2015). In addition, broad phenotypic diversity is observed in the characters of plant height, number of seeds per plant, and weight of 100 grains. In contrast, narrow criteria are observed in the characters of seed length, seed width, and seed thickness. Characters with broad genetic diversity tend to have broad phenotypic diversity, whereas those with narrow genetic diversity do not necessarily have narrow phenotypic diversity (Priyanto et al., 2018). The appearance of these characters shows that phenotype is an interaction between genetics and the environment (Syukur et al., 2010). Research by Wijaya et al. (2024) found that broad phenotypic diversity in a character indicates that both genetics and the environment influence its appearance.

The heritability values of the analyzed seed characters fall into low, medium, and high categories. The 100-grain weight character shows a high heritability value, and plant height, seed length, seed width, seed thickness, and number of seeds per plant show medium heritability. In contrast, the seed weight per plant character shows low heritability (Table 3). The 100-grain weight character has a high heritability (73%) and broad genetic diversity, indicating that genetic influence is powerful and that this character can be used as a selection criterion in the F3 generation. A high heritability value indicates that a trait is inherited easily and is readily passed on to offspring

(Maulana et al., 2023). In line with the research of Annicchiarico et al. (2010), the high genetic diversity is due to the strong contribution of genetic factors to total diversity. The high value of heritability is influenced by genetic factors that play a greater role than environmental factors (Bornhofen et al., 2017). Selection can be applied efficiently to traits with high heritability (Amien et al., 2022). A plant controlled by genetic factors can be used for selection because it can pass these traits on to subsequent generations (Mukhopadhyay & Bhattacharjee, 2016). Silva et al., (2021); Meriaty et al. (2021) reported that high heritability values in early generations increase the effectiveness of selection and genetic progress in subsequent generations.

Seed length, width, and thickness traits exhibit moderate heritability and broad genetic diversity. This indicates that despite environmental influences, genetic components are strong enough to control the expression of these traits, allowing selection to occur in early generations. A study by Verma et al. (2024) on 247 soybean genotypes also found high genetic and phenotypic coefficients of variance (GCV) for biological and production traits, indicating the potential for selection despite environmental influences.

In contrast, the seed weight per plant trait in this study had very low heritability (2%) with limited genetic diversity. This suggests that the expression of this trait is more influenced by environmental factors than genetics, or by genotype × environment (G × E) interactions. Bianchi et al. (2020) emphasized that G × E interactions can lower the effective heritability estimate of a trait, making traits with significant environmental influences less stable for early selection. Furthermore, genotype × environment interactions on crop yield (and related traits) are frequently observed in later-generation studies. Susanto et al. (2023) reported that soybean yield traits are strongly influenced by G × E interactions, which can cause superior genotypes in one environment to be less superior in another. Therefore, traits such as seed weight per plant, with low heritability and limited genetic diversity, are less suitable as a basis for early-generation selection. This character selection is better carried out in later generations (when genetic variability is more stable/homozygous), and ideally tested in several environments (multi-location test) so that environmental influences and G×E interactions can be controlled or evaluated.

Seed weight per plant depends on the metabolic processes occurring within the plant during seed formation and filling. When the environment is not conducive to these processes, seed formation and weight are suboptimal. Planting during the rainy season disrupts seed formation and filling, due to factors such as insufficient light intensity (Li et al., 2024) and unbalanced nutritional conditions (Skidmore & Coppess, 2023).

To increase seed yield, beyond genetic factors, environmental factors must be addressed, including the agroecosystem and cultivation practices. Because environmental factors such as humidity, rainfall, groundwater availability, temperature, and cultivation management significantly influence seed yield, particularly during the rainy season, yield improvement alone is not sufficient. Approximately 50% of the overall genetic influence on seed yield is accounted for by additive effects, epistasis, and dominance (gene dominance). Tayade et al. (2023) reported that additive genetic effects primarily controlled soybean yield across six biparental crosses, but genotype × environment (G × E) interactions significantly reduced the stability of yield phenotype expression. This suggests that selection focused solely on genetic components will not be optimal without considering environmental variation. Thus, for traits that are significantly influenced by non-additive or dominant effects and G×E interactions, such as seed weight per plant, in this study, the initial selection strategy needs to be complemented by good environmental management (drainage, fertilization, disease control, plant spacing) and testing in several environments (multi-location), especially during the rainy season. This is important so that dominant and epistatic effects, and environmental variation, do not obscure additive genetic potential, enabling selection to be effective and seed yield to increase. Similarly, Tayade et al. (2023) found that 100-seed weight had the most significant potential for selection advantage. However, genotypic stability varied across environments, particularly during the rainy season with high rainfall and excessive humidity. This indicates that improving seed yield requires a dual approach: consistent utilization of additive, heritable genetic traits and appropriate environmental management to minimize the negative environmental impacts of the rainy season.

Genotype response to rainy season environment and breeding implications

Based on the research results, soybean breeding strategies to obtain superior, adaptive genotypes in the rainy season should focus on seed characters with moderate to high heritability and broad genetic diversity, particularly 100-grain weight. These characters are more stably expressed despite environmental influences, allowing selection to be carried out more effectively in the early generations (F3–F4). Genotype UM002, which shows a higher number of seeds per plant than the check cultivar, is a potential candidate for further selection, as this trait is thought to be inherited from the cross parent (Gepak Kuning × Detam 4), which is adaptive in humid environments.

Selection cannot be carried out solely under one environmental condition. Multi-location and multi-season trials, particularly in areas with high humidity during the rainy season, are necessary to identify genotypes with stable yields. The multi-trait selection index (MTSI) or multi-environment trials (MET) approach, as reported by Kumar et al. (2025), can be used to accelerate the identification of superior genotypes that are not only high-yielding but also adaptive to the environmental stresses of the rainy season. Therefore, soybean breeding programs in Indonesia should integrate genetic parameter-based selection (heritability and genetic diversity) with environmental adaptation testing to produce new cultivars that are superior, stable, and suitable for planting in the rainy season.

CONCLUSION

The UM002 line showed better seed number performance per plant compared to two check varieties, Deja 2 and Detam 4, which can be used as a promising soybean line that is adaptive to the rainy season. The 100-grain weight character showed a high heritability value. This indicates that the 100-grain weight character can be used as a selection criterion for soybeans during the rainy season in an effort to increase selection effectiveness. The availability of promising lines with high yield potential and characters as adaptation markers for the selection process during the rainy season can accelerate the process of developing varieties that are adaptive to the rainy season.

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