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Response of Two Rice Varieties (*Oryza sativa* L.) to Close Planting Distances

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Abstract: Rice (*Oryza sativa* L.) plays an important role as a major food source to meet the needs of densely populated communities. The use of superior varieties and planting at the right distance can significantly increase production, thereby supporting optimal growth and maximum yields. This study was conducted from July to October 2023. This research was arranged in a factorial randomized block design (RBD), involving two factors: the first factor included dense planting distances, namely 40 cm × 25 cm × 25 cm, 30 cm × 25 cm × 25 cm, and 20 cm × 25 cm × 25 cm; while the second factor was rice varieties, namely Ciherang and Situbagendit. The analysis of the results showed that the interaction between planting distance and variety did not have a significant effect on the various parameters measured. However, the 30 cm × 25 cm × 25 cm planting distance produced superior performance in most growth and production indicators, such as plant height reaching 92.31 cm, number of tillers 22.64, number of panicles 16.72, and grain weight per plot 413.50 g. The Situbagendit variety also stood out with optimal results compared to Ciherang, as seen in plant height of 94.95 cm, dry weight of 67.88 g, and weight of 1,000 grains of 278.46 g. The absence of significant interaction indicates that the effect of planting distance is more due to competition between individual plants, while variety differences are more dependent on genetic characteristics. Therefore, the combination of a 30 cm × 25 cm × 25 cm planting distance with the Situbagendit variety is recommended as the optimal choice for increasing rice plant productivity.

Keywords: planting distance, plant population, rice productivity

1. Introduction

Rice (*Oryza sativa* L.) plays a crucial role as a primary food source for the majority of Indonesians. However, its availability still relies on imports from other countries. Rapid population growth has significantly increased demand for rice. To address this imbalance between food demand and supply, intensive efforts are needed to increase rice production (Zaqiah et al., 2019). Similarly, Prasetyo and Kadir (2019) emphasized that increasing national production can be achieved through expanding planted areas and optimizing yields per unit area.

Varieties play a crucial role in increasing rice production and farmer incomes through the application of efficient technology. Varieties are groups of plants with unique characteristics that are stable even when planted extensively. Variety selection needs to be tailored to land conditions. High-yielding superior varieties have been proven to increase national production, as evidenced by the achievement of food self-sufficiency in 1984. Therefore, the development of new superior varieties is a key strategy for increasing rice production (Nyoman et al., 2018). Furthermore, proper plant spacing plays a crucial role in providing optimal growing space so that plants do not compete for water, nutrients, and light (Turiono et al., 2018). Plant spacing affects population density, tiller number, and yield, with wide spacings allowing for more tiller production, while narrow spacings limit it (Suryanto et al., 2018). However, spacing that is too wide can decrease land use efficiency and reduce total yield (Magfiroh et al., 2017).

Rice variety selection and plant spacing are interrelated in determining productivity, as each variety requires a specific spacing for optimal growth and yield; a mismatch between the two can hinder plant development and reduce yield (Sutaryo, 2019). Further research is needed to determine the most effective combination of variety and plant spacing.

2. Materials and Methods

This research was conducted from July to October 2023 in Pakis Village, Panti District, Jember Regency. At an altitude of 333 meters above sea level, with coordinates between 8°7'22" South Latitude and 113°35'45" East Longitude, the air temperature was around 22°-31°C, and the humidity was around 74-97%.

The tools used included a watering can, a power sprayer, a measuring tape, raffia rope, a machete, a bucket, bamboo poles/stakes, a cutter knife, scissors, a camera, and stationery. The materials used were Situbagendit and Ciherang rice seeds, NPK, urea, KCL, and SP-36 fertilizers.

This research was conducted using a factorial randomized block design (RBD). The study involved two main factors: rice plant spacing, divided into three levels, and rice variety, divided into two levels.

Specifically, this study employed two factors: plant spacing and rice variety. The plant spacing factor comprised three levels: V1 at 40 cm × 25 cm × 25 cm, V2 at 30 cm × 25 cm × 25 cm, and V3 at 25 cm × 25 cm × 25 cm. The rice variety factor consisted of P1, the Ciherang variety, and P2, the Situbagendit variety.

The combination of these two factors formed six treatments, including P1V1 (Ciherang with a planting distance of 40 cm × 25 cm × 25 cm), P1V2 (Ciherang with a planting distance of 30 cm × 25 cm × 25 cm), P1V3 (Ciherang with a planting distance of 25 cm × 25 cm × 25 cm), P2V1 (Situbagendit with a planting distance of 40 cm × 25 cm × 25 cm), P2V2 (Situbagendit with a planting distance of 30 cm × 25 cm × 25 cm), and P2V3 (Situbagendit with a planting distance of 25 cm × 25 cm × 25 cm). This study was repeated three times, resulting in a total of 18 experimental plots. Each plot was planted with 24 plants, with spacings of 40 cm × 25 cm × 25 cm, 30 cm × 25 cm × 25 cm, and 25 cm × 25 cm × 25 cm. Six plants were then sampled from each plot for in-depth observation.

3. Results and Discussion

Summary of ANOVA Results

From the study on the Impact of Close Planting Spacing on the Growth and Production of Several Rice Varieties, eight observation variables were identified: plant height, number of tillers, number of harvested panicles, dry stalk weight, wet grain weight, dry grain weight, grain weight per plot, and 1,000-grain weight [5]. The following is a summary of the analysis of variance results for these observation variables, presented in Table 3.1 below:

Table 3.1 Summary of Variance Analysis Results for Observation Variables

No	Observation Variable	F-Value		
		Planting Distance (V)	Variety (P)	Interaction (V x P)
1.	Plant Height (cm)	7,46*	99,04**	3,96 ns
2.	Number of Tillers (tillers)	6,65*	6,05*	0,67 ns
3.	Number of Panicles (panicles)	6,66*	5,23*	0,04 ns
4.	Plant Biomass (g)	0,21 ns	6,77*	3,54 ns
5.	GrainWeight/Panicle (g)	5,97*	13,16**	0,07 ns
6.	Grain Weight/Plot (g)	6,74*	5,38**	0.03 ns
7.	Dry Grain Weight/Plot (g)	6,12*	11,29*	0,11 ns
8.	Weight of 1000 Grain (g)	7,55*	22,39**	0,24 ns

Description: The notation indicates results that are not significantly different (ns), significantly different (*), and significantly different (**).

Plant Height (cm)

The results of measurements of the effect of plant spacing on plant height showed that the dense spacing treatment had a significantly different effect. Therefore, further testing was conducted using LSD at the 5% level to more specifically determine differences between treatments. The results of this test can be seen in Figure 3.1 below.

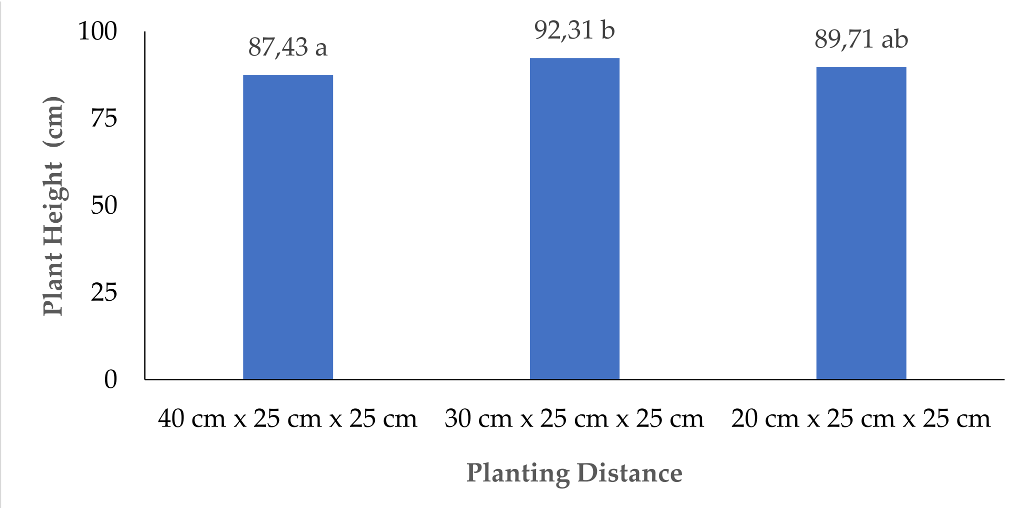

Figure 3.1 Rice Plant Height at Different Planting Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the results of the 5% LSD test.

From Figure 4.1, it can be seen that the planting distance arrangement of 30 cm × 25 cm × 25 cm produces an average plant height of 92.31 cm, which is not significantly different from the arrangement of 20 cm × 25 cm × 25 cm, but is significantly different compared to the arrangement of 40 cm × 25 cm × 25 cm. Therefore, to support plant height growth, the planting distance arrangement of 30 cm × 25 cm × 25 cm can be an option because it provides optimal growth results and is significantly superior to arrangements with wider planting distances.

Table 3.2 Height of Rice Plants of 2 Different Varieties

Varieties	Plant Height (cm)
Ciherang	84,68 b
Situbagendit	94,95 b

Description: Numbers followed by different lowercase letters indicate a significantly different effect based on the results of the BNT test at 1% level.

Based on Table 3.2, the Situbagendit variety showed the highest plant height, with an average of 94.95 cm, which was significantly different from the Ciherang variety. Therefore, to support plant growth, the Situbagendit variety can be used.

Number Of Tillers

Based on the ANOVA recapitulation results in Table 3.1, the dense spacing treatment showed a significantly different effect on the number of tillers, so a further test was conducted using the Least Significant Difference at the 5% level. The results of the 5% BNT further test can be seen in Figure 3.2 below:

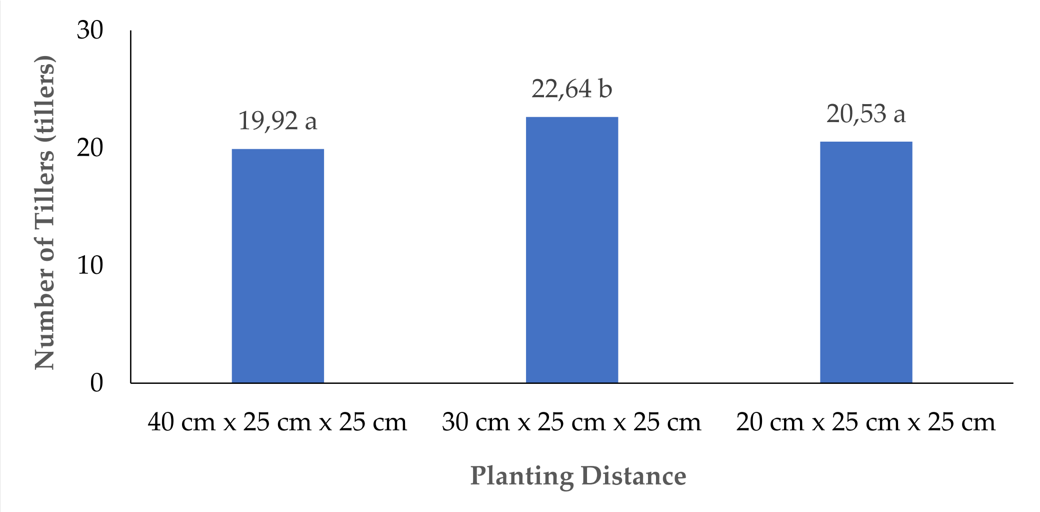

Figure 3.2 Number of Rice Tillers at Different Plant Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the results of the LSD test at the 5% level.

From Figure 3.2, it can be seen that the planting distance of 30 cm × 25 cm × 25 cm produces an average number of tillers of 22.64, which is significantly different compared to the arrangement of 40 cm × 25 cm × 25 cm and 20 cm × 25 cm × 25 cm. Therefore, to increase the number of tillers, the planting distance of 30 cm × 25 cm × 25 cm can be the main choice, because it provides optimal results and is significantly superior to arrangements with wider or narrower distances.

Table 3.3 Number of Rice Tillers of 2 Different Varieties

Varieties	Number Of Tillers
Ciherang	20.24 a
Situbagendit	21,81 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 5% LSD test results.

Based on Table 3.3, the Situbagendit variety showed the highest number of tillers, with an average of 21.81 tillers, significantly different from the Ciherang variety. Therefore, to support increased tiller numbers, the Situbagendit variety can be used.

Number of Harvested Panicles

Based on the ANOVA recapitulation results in Table 3.1, the dense planting spacing treatment showed a significantly different effect on the number of harvest panicles, so further testing was carried out using LSD (Smallest Significant Difference) at the 5% level.

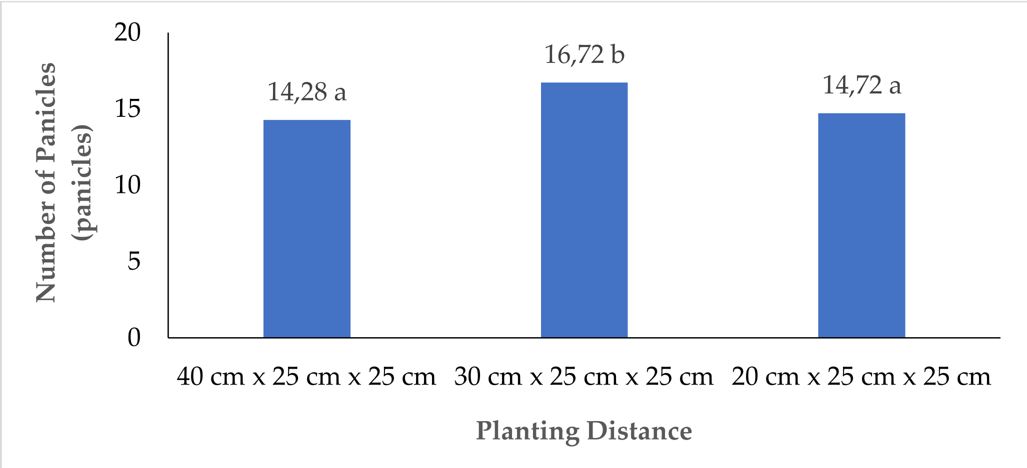

Figure 3.3 Number of Harvested Panicles at Different Planting Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the results of the LSD test at the 5% level.

Figure 3.3 shows that a planting spacing of 30 cm × 25 cm × 25 cm resulted in an average harvested panicle of 16.72 panicles, significantly different from the 40 cm × 25 cm × 25 cm and 20 cm × 25 cm × 25 cm spacings. Therefore, to increase the number of harvested panicles, a planting spacing of 30 cm × 25 cm × 25 cm can be the primary choice, as it provides optimal results and is significantly superior to wider or narrower spacings.

Table 3.4 Number of Rice Panicles of 2 Different Varieties

Varietas	Number of Harvest Panicles
Ciherang	14,57 a
Situbagendit	15,91 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 5% LSD test results.

Based on Table 3.4, the Situbagendit variety showed the highest number of harvested panicles, with an average of 15.91 panicles, significantly different from the Ciherang variety. Therefore, to support increased panicle yields, the Situbagendit variety can be used.

Dry Plant Weight (g)

The results of the 5% BNT further test of the variety treatment on the dry weight variable can be seen in Table 3.5 below:

Table 3.5 Dry Weight of Rice from 2 Different Varieties

Varietas	Dry Plant Weight (g)
Ciherang	55,35 a
Situbagendit	67,88 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 5% LSD test results.

Table 3.5 shows that the Situbagendit variety exhibited the highest dry weight with an average of 67.88 g, significantly different from the Ciherang variety. Therefore, to support increased dry weight, the Situbagendit variety can be used.

Grain Weight per Panicle (GKS)

Based on the ANOVA recapitulation results in Table 3.1, the dense spacing treatment showed a significantly different effect on fresh grain weight, so further testing was carried out using LSD (Least Significant Difference) at the 5% level. The results of the 5% LSD further test can be seen in Figure 3.4 below:

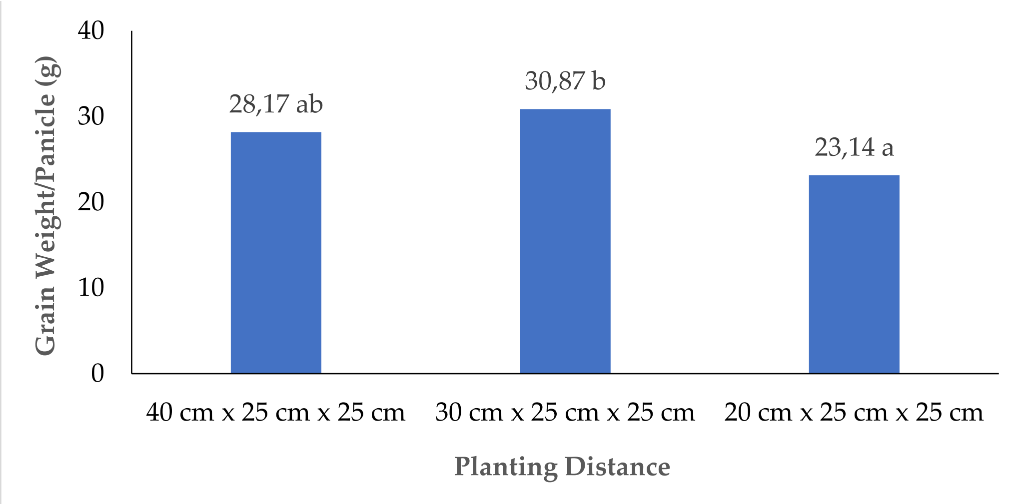

Figure 3.4 Grain Weight/Panicle at Different Plant Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the 5% LSD test results.

According to Figure 3.4, a plant spacing of 30 cm × 25 cm × 25 cm produced the highest fresh grain weight (30.87 g). This was not significantly different from the 40 cm × 25 cm × 25 cm spacing, but significantly different from the 20 cm × 25 cm × 25 cm spacing. Therefore, a spacing of 30 cm × 25 cm × 25 cm is recommended for optimal yields. The results of the 5% LSD test on the fresh grain weight variable are shown in Table 3.6 below:

Table 3.6 Wet Grain Weight of Rice of 2 Different Varieties

Varietas	Grain Weight per Panicle (g)
Ciherang	24,03 a
Situbagendit	30,76 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 1% BNT test results.

Based on the 1% BNT test, the Situbagendit variety produced the highest fresh grain weight (30.67 g) and was significantly different from the Ciherang variety. Therefore, this variety has the potential to be used to increase fresh grain yield.

Grain Weight/Plot (GKS)

Based on the ANOVA recapitulation results in Table 3.1, the dense spacing treatment showed a significantly different effect on dry grain weight, so further testing was carried out using the Least Significant Difference at the 5% level. The results of the 5% BNT further test can be seen in Figure 3.5 below:

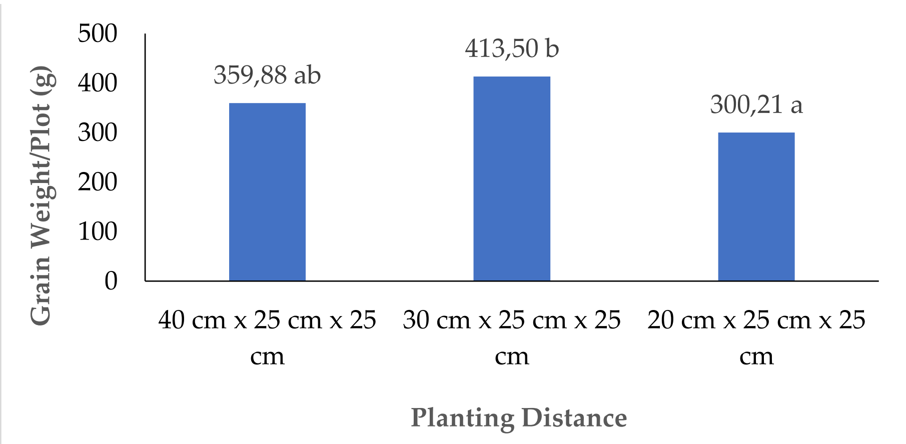

Figure 3.5 Grain Weight/Plot at Different Plant Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the 5% LSD test results.

From Figure 3.5, it can be concluded that a planting spacing of 30 cm x 25 cm x 25 cm produces an average dry grain weight of 23.95 g. This result does not show a significant difference compared to a planting spacing of 40 cm x 25 cm x 25 cm, but is significantly different compared to a planting spacing of 20 cm x 25 cm x 25 cm. Therefore, to support increased dry grain weight, a planting spacing of 30 cm x 25 cm x 25 cm is recommended, as it provides optimal results and provides a significant difference compared to closer planting spacing.

Table 3.7 Grain Weight Per Plot of Rice of 2 Different Varieties

Varietas	Berat Gabah/Plot (g)
Ciherang	18,65 a
Situbagendit	23,63 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 1% LSD test results.

Table 3.7 shows that the Situbagendit variety exhibited the highest dry grain weight, with an average of 23.63 g, significantly different from the Ciherang variety. Therefore, to support increased dry grain weight, the Situbagendit variety can be used, as it yields higher yields than other varieties.

Dry Grain Weight/Plot (g)

Based on the ANOVA recapitulation results in Table 3.1, the dense planting spacing treatment showed a significantly different effect on grain weight per plot, so further testing was carried out using BNT (Smallest Significant Difference) at the 5% level.

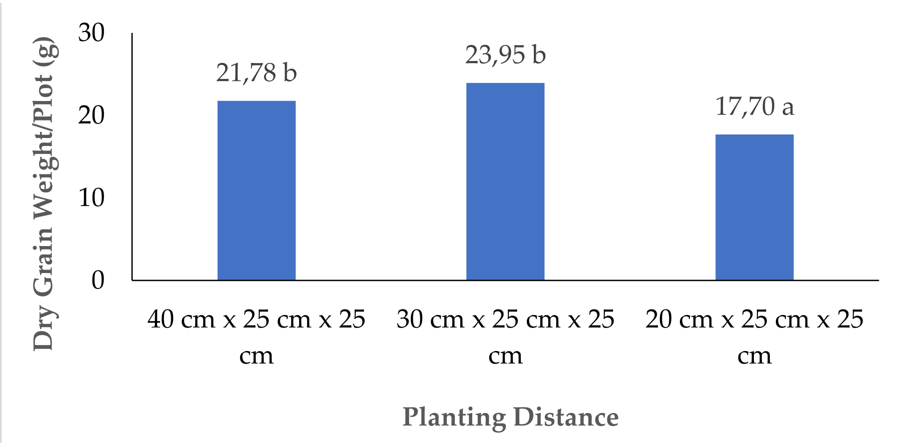

Figure 3.6 Dry Grain Weight/Plot at Different Planting Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the results of the LSD test at the 5% level.

According to Figure 3.6, a planting spacing of 30 cm × 25 cm × 25 cm produced the highest grain weight per plot (413.50 g). This was not significantly different from the 40 cm × 25 cm × 25 cm spacing, but significantly different from the 20 cm × 25 cm × 25 cm spacing. Therefore, a spacing of 30 cm × 25 cm × 25 cm is recommended for optimal yields. The results of further 5% LSD testing of variety treatments on the grain weight per plot variable can be seen in Table 3.8 below:

Table 3.8 Dry Grain Weight per Rice Plot of 2 Different Varieties

Varietas	Dry Weight/Plot (g). (g)
Ciherang	328,64 a
Situbagendit	387,08 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 5% LSD test results.

Table 3.8 shows that the Situbagendit variety has the highest grain weight per plot (387.08 g) and is significantly different from Ciherang. Therefore, it can be used to increase grain yield per plot.

1000-Grain Weight

Based on the ANOVA recapitulation results in Table 3.1, the dense planting distance treatment showed a significantly different effect on the weight of 1000 grains, so a further test was carried out using the Least Significant Difference (LSD) at the 5% level. The results of the 5% LSD further test can be seen in Figure 3.7 below:

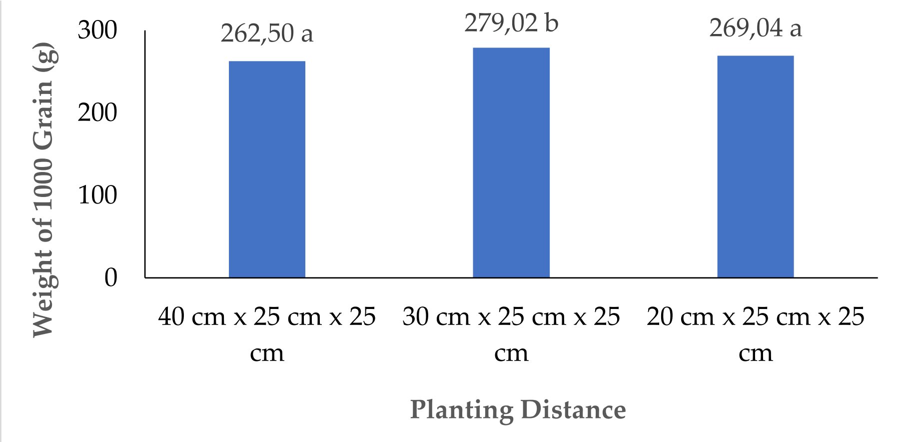

Figure 3.7. Weight of 1000 Grains at Different Planting Spacings

Note: Numbers followed by different lowercase letters indicate significantly different effects based on the 5% LSD test results.

Figure 3.7 shows that a planting spacing of 30 cm x 25 cm x 25 cm resulted in an average 1,000-grain weight of 279.02 g, significantly different from spacings of 40 cm x 25 cm x 25 cm and 20 cm x 25 cm x 25 cm. Therefore, to support increased 1,000-grain weight, a planting spacing of 30 cm x 25 cm x 25 cm is recommended, as it provides optimal results and offers significant differences compared to wider or closer spacings.

Table 3.9 Weight of 1000 Grains of Rice of 2 Different Varieties

Varietas	Berat 1000 Butir (g)
Ciherang	261,92 a
Situbagendit	278,46 b

Note: Numbers followed by different lowercase letters indicate a significantly different effect based on the 1% LSD test results.

Table 3.9 shows that the Situbagendit variety exhibited the highest 1,000-grain weight, with an average of 278.46 g, significantly different from the Ciherang variety. Therefore, to support increased 1,000-grain weight, the Situbagendit variety can be used, as it yields higher yields than other varieties. Rice production is influenced by the interconnected vegetative growth and yield. Yield components such as panicle number, grain weight, and 1,000-grain weight reflect the plant's ability to absorb water and nutrients, and photosynthesize (Khairil et al., 2020). Plant spacing is a crucial factor because it determines the level of competition between plants for resources. Each variety has different growth characteristics, so responses to plant spacing also vary (Syafiqa et al., 2024).

Observations showed that a plant spacing of 30 × 25 × 25 cm produced a plant height of 92.31 cm and 22.64 tillers, compared to 20 × 25 × 25 cm, which produced 89.71 cm and 20.53 tillers. This indicates that a plant spacing of 30 × 25 × 25 cm creates more optimal growing conditions. Spacing that is too close causes competition for light and nutrients, while spacing that is too wide reduces nutrient uptake efficiency (Harini et al., 2021). Balanced spacing also increases the number of productive tillers because root development is not hampered by excessive competition (Amiroh et al., 2020). According to Fadhillah et al. (2021) proportional spacing optimizes growing space and reduces unproductive tillers. The Situbagendit variety showed better growth than Ciherang, with a plant height of 94.95 cm, a tiller count of 21.82, and a dry panicle weight of 67.88 g. This demonstrates the influence of genetics and the variety's adaptation to the environment.

In addition, a planting distance of 30 × 25 × 25 cm produced the highest number of panicles (16.72 panicles) as well as the best results in terms of wet seed weight (30.87 g), dry seed weight (23.95 g), weight per plot (413.50 g), and weight of 1,000 seeds (279.02 g). Although not significantly different from a planting distance of 40 cm, the results were still better than 20 cm, indicating that balanced planting distance can reduce competition and increase nutrient absorption efficiency.

4. Conclusions

Based on the research results, the following conclusions can be drawn: (1) There was no significant interaction between planting distance and variety for all observed parameters; (2) Analysis of the results showed that variety significantly affected rice growth and yield. The Situbagendit variety, with its genetic superiority, demonstrated the best results in various growth and production parameters compared to the Ciherang variety. These parameters included plant height (94.95 cm), number of tillers (21.82), number of panicles (15.91), dry stalk weight (67.88 g), wet grain (30.67 g), dry grain (23.63 g), yield per plot (387.08 g), and 1,000-grain weight (278.46 g); and (3) Plant spacing significantly affected rice growth and yield. A plant spacing of 30 cm × 25 cm × 25 cm achieved optimal results in various growth and production parameters, underscoring the importance of integrating superior varieties with appropriate spacing to maximize crop productivity.

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