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Optimizing Rice Plants (*Oryza sativa* L.) Growth and Yield in Various Planting Systems by Providing Paclobutrazol Concentration

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Abstract

Rice (*Oryza sativa* L.) is the primary staple food crop and a strategic source of carbohydrates for the Indonesian population. In recent years, rice production has declined at both national and local levels due to climate change, land limitations, and pest disturbances. This condition highlights the urgent need for research to develop more efficient and sustainable rice cultivation strategies. This study aimed to determine the interactive effects of planting systems and Paclobutrazol concentrations on the growth and yield of the rice variety Inpari 32. The research was conducted in Ngraho District, Bojonegoro Regency, East Java, using a Split Plot Design with two factors: planting systems (Tegel/traditional, SRI, Legowo 2:1, and modified Legowo) and Paclobutrazol concentrations (0, 600, 700, and 800 ppm). Observed parameters included plant growth and yield components. The results revealed significant interactions between planting systems and Paclobutrazol concentrations on several parameters, including the number of panicles, panicle length, and grain weight per cluster. The best results were obtained with the modified Legowo system combined with 600 ppm Paclobutrazol, which produced yields exceeding 6 tons per hectare. This combination is recommended as an effective cultivation strategy to enhance rice productivity and support sustainable national food security.

Keywords: Food Safety, Paclobutrazol, Planting system, Productivity, Rice (*Oryza sativa* L.)

1. Introduction

Rice (*Oryza sativa* L.) is a major food crop that has a strategic role in the national food supply. Rice production in each region generally fluctuates. This result is attributed to the presence of limiting factors that can impact rice production, including climate and pest factors (Ezward et al., 2022). In Indonesia, rice is the staple food of the majority of the population, so increasing its productivity is crucial to ensure national food security. However, rice production often fluctuates due to climate factors, pest attacks, diseases, and limited agricultural land. Data from the Central Statistics Agency (2023) shows that national rice production has decreased by 2.05% from 31.54 million tons in 2022 to 30.90 million tons in 2023. At the local level, such as in Ngroho District, Bojonegoro Regency, rice production has also decreased from 31,366 tons in 2022 to 27,260 tons in 2023 (Food Security and Agriculture Service, 2023). This decline shows the need for innovation in the rice cultivation system.

One effort that can be made to increase crop yields is through the implementation of the proper planting system. Various planting systems have been developed, including the Tegel system (traditional), jajar Legowo, and the System of Rice Intensification (SRI), each with its advantages. The Jajar Legowo planting system is known to increase productivity by enhancing the intensity of light received by plants and reducing competition between them (Ningrat et al., 2021). In addition to the planting system, the use of plant growth regulators (PGRs) plays a crucial role in supporting plant growth and yields. One type of PGR that is widely used is Paclobutrazol, which is included in the retardant group. Retardant PGRs work by inhibiting the biosynthesis of the gibberellin hormone, which functions in stem elongation and vegetative growth of plants. With this inhibition, vegetative growth is suppressed, allowing the plant's metabolic energy to be directed more toward the process of forming generative organs, such as panicles and seeds (Prihantari et al., 2022).

The use of Paclobutrazol has been proven to shorten and strengthen plant stems, increase resistance to lodging,

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and improve the quality of the harvest. Several previous studies have shown the effectiveness of Paclobutrazol in increasing the growth and yield of rice plants. For example, (2022) reported that paclobutrazol can inhibit vegetative plant growth, including a reduction in plant height. Tambajong et al. (2016) reported that administering Paclobutrazol in the SRI planting method can increase the number of panicles and dry-milled grain yields. (2019) also found that the optimal concentration and timing of Paclobutrazol application can increase the yield of the Serayu rice variety. Research by Lutfiana et al. (2023) concluded that the appropriate dose of Paclobutrazol can increase grain weight and plant stem resistance. (Fauziah *et al* ., 2024) . On the other hand, the Legowo row planting system has also been proven to produce longer panicles and higher grain weights compared to the tile system (Adnyana, 2020).

However, most previous studies have only focused on one variable, such as the Paclobutrazol dose or a particular planting system, separately. In contrast to these studies, this study examines the interaction between various planting systems (tiles, SRI, 2:1 jajar Legowo, and modified jajar Legowo) with various concentrations of Paclobutrazol (0, 600, 700, and 800 ppm) simultaneously. This approach is expected to provide a more comprehensive understanding of the optimal treatment combination, which can significantly and sustainably enhance rice plant growth and yield. Based on this description, this study aims to determine the effect of interaction between various planting systems and Paclobutrazol concentrations on the development and yield of Inpari 32 rice plants. The hypothesis proposed is that the modified Jajar Legowo planting system, administered with 600 ppm Paclobutrazol, has the best effect on rice plant growth and yield (*Oryza sativa* L.).

2. Material and Methods

This research was conducted from December 2024 to March 2025 in agricultural land in Ngraho Village, Ngraho District, Bojonegoro Regency, East Java, which is located at coordinates 7°10'15" South Latitude and 111°39'42" East Longitude, with an altitude of ±85 meters above sea level at an altitude of 25–500 meters above sea level, with dry muddy soil texture, temperatures ranging from 27°C–38°C, rainfall of 1500–2500 mm/year, and air humidity between 65%–90%. The tools used in this study include hoes, tractors, meters, rulers, raffia ropes, knives, scales, and stationery. The materials used include Inpari 32 variety rice seeds, NPK Phonska and Urea fertilizers, plant labels, and Paclobutrazol growth regulators.

This study employed a split-plot design with two treatment factors. The first factor was the planting system (as the main plot) consisting of four levels, namely the tile planting system (traditional), SRI (*System of Rice Intensification*), 2:1 Legowo row system, and modified Legowo row system. The second factor was the concentration of Paclobutrazol (as a subplot), which also consisted of four levels: 0 ppm (control), 600 ppm, 700 ppm, and 800 ppm. There were a total of 16 treatment combinations, each repeated three times, resulting in 48 experimental units. Planting was carried out with a spacing pattern appropriate to each system, with three seedlings per clump for the tile, Legowo row, and modified Legowo row systems, and one seedling per clump for the SRI planting system.

Paclobutrazol was applied by spraying the leaves twice, at 21 and 42 days after planting (DAP), carried out in the morning between 07:00 and 09:00 WIB. Fertilization was carried out three times: basic fertilization using NPK at 100 g/5 m² at 7 DAP, followed by two follow-up fertilization with urea at 75 g/5 m² each at 21 DAP and 35 DAP. Harvesting was carried out when the plants were 115–117 days after planting by cutting the base of the stem using a sickle.

The parameters observed included growth and yield components. Primary data were processed using Microsoft Excel 2019, while statistical analysis, including analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT), was performed using IBM SPSS Statistics version 26. To obtain accurate information on the research location's coordinates, Google Earth Pro version 7.3.6.9345 was used. The combination of field tools and digital applications aims to enhance measurement accuracy and analysis reliability, thereby supporting the reliability of scientific research conclusions.

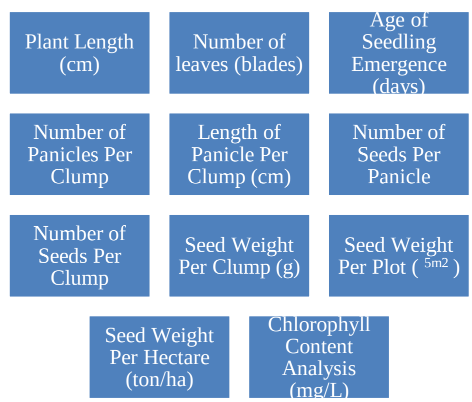

Figure 1. Research Parameter Flowchart

3. Results and Discussion

3.1. Plant Length

The results of the analysis of variance showed that the combination of treatments of various planting systems with paclobutrazol concentrations had a significant effect on the length of rice plants at the age of 35, 42, 49, and 56 HST. The average length of rice plants in the combination of various planting systems and paclobutrazol concentrations at the age of 35 HST to 56 HST is presented in Table 1.

Table 1. Shows that the length of rice plants gave a

significant response to the interaction of planting systems and Paclobutrazol concentrations at the ages of 35, 42, 49, and 56 HST. The maximum length was recorded in the treatment without Paclobutrazol (0 ppm) with a modified Legowo planting system, indicating that vegetative growth was more optimal without inhibition of gibberellin synthesis. This result aligns with the function of Paclobutrazol as an inhibitor of stem elongation (Silitonga and Nasution, 2019).

Table 1Average Length of Rice Plants at Age 35 – 56 HST in Combination of Planting System Treatment and Paclobutrazol Concentration

Age (HST)	Paclobutrazol Concentration (ppm)	Plant Length (cm)			
		Planting System			
		Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
35	0	45.70±1.02 bc	44.94±0.43 bc	45.89±1 c	45.09±0.79 bc
	600	42.71±1.89 ab	42.14±0.51 ab	42.88±1.02 ab	43.22±1.41 b
	700	42.22±1.08 ab	42.18±0.92 ab	43.49±0.7 bc	40.38±0.98 a
	800	44.26±1.25 bc	42.80±0.92 ab	42.85±0.74 ab	42.28±0.08 ab
	BNJ 5%	2.65			
42	0	50.37±2.32 b	49.87±0.88 ab	54.10±0.87 bc	56.83±1.76 c
	600	46.37±1.88 a	48.67±1.23 ab	49.12±1.61 ab	53.89±0.52 bc
	700	46.74±1.81 ab	49.32±0.78 ab	49.57±1.01 ab	48.33±1.1 ab
	800	48.58±2.35 ab	49.12±0.26 ab	47.83±1.15 ab	51.62±1.78 b
	BNJ 5%	3.91			
49	0	55.38±3.78 ab	55.00±0.78 ab	59.58±0.29 b	62.23±0.43 b
	600	52.28±3.49 a	54.93±0.61 ab	54.67±1.18 ab	59.15±0.18 b
	700	50.60±1.52 a	54.16±0.64 ab	55.28±0.72 ab	53.02±0.81 ab
	800	52.29±2.43 a	53.88±0.45 ab	53.98±1.18 ab	58.17±1.53 b
	BNJ 5%	5.18			
56	0	60.73±4 ab	61.01±1.22 ab	67.13±0 b	67.09±0.72 b
	600	57.77±3.36 ab	61.29±0.5 ab	60.97±1.32 ab	64.64±0.19 b
	700	55.52±1.83 a	60.01±0.2 ab	61.08±0.43 ab	57.45±1.26 ab
	800	57.00±2.17 ab	60.41±0.81 ab	60.17±1.24 ab	62.55±3.53 b
	BNJ 5%	5.87			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

This finding is in line with the study by Tambajong et al. (2016), which reported a decrease in stem length due to Paclobutrazol application. However, this study demonstrates that the impact can be optimized through the use of a proper planting system, such as modified Legowo rows, which facilitate high light penetration and enhanced photosynthesis efficiency. Physiologically, this suppression of stem growth is not an indication of stress but rather a form of plant metabolic efficiency, where energy and assimilates are more diverted to the process of forming tillers and panicles, thus supporting an increase in overall yield.

3.2. Number of Leaves

The results of the analysis showed that the combination of the planting system and paclobutrazol had no significant effect on the number of rice leaves (*Oryza sativa* L.). The average number of rice plant leaves in various planting systems, and paclobutrazol concentrations are presented in Table 2. Table 2 shows that the number of leaves is significantly affected by the planting system treatment, particularly during the early growth stage (7–35 HST). The Jajar Legowo planting system and its modifications produce more leaves than the SRI and Tegel systems. This result suggests that a more spaced plant arrangement enhances the efficiency of light absorption for photosynthesis, leading to improved leaf formation (Martina and Pebriandi, 2020).

These results align with those of Tambajong et al. (2016), who also found that a planting system regulating plant spacing can increase the number of leaves and canopy area. Physiologically, this can be explained by the increased distribution of light to all parts of the plant, which encourages chlorophyll activity and accelerates cell division in meristem tissue. With good lighting and air circulation, plants are more efficient in producing cytokinin hormones that stimulate leaf growth, in accordance with the physiological mechanisms explained by Silitonga and Nasution (2019).

3.3. Number of Offspring

The results of the analysis of variance showed that the combination of treatments between various planting systems and paclobutrazol concentrations did not have a significant effect on the number of rice plant tillers (*Oryza sativa* L.). The average number of tillers in the treatment of planting systems and paclobutrazol concentrations for rice plants aged 7-28 HST is presented in Table 3.

Table 3. Shows that the number of tillers is significantly influenced by the planting system, where the modified Legowo system produces the most tillers. A more open planting pattern increases light and growing space, encouraging more active budding. This finding aligns with Adnyana (2020) and Suharno and Isnayanti (2018), who reported an increase in the number of tillers in the 2:1 Legowo system. In contrast, Paclobutrazol had no significant effect because it played a greater role in inhibiting stem elongation (Silitonga and Nasution, 2019).

Table 2. Average Number of Rice Leaves at Age 7 – 28 HST in Planting System and Paclobutrazol Concentration Treatments

Treatment	Number of leaves			
	7 HST	**14 HST**	**21 HST**	**28 HST**
Planting System				
Traditional	7.98 ± 1.34 b	12.02 ±1.35 b	30.21 ±2.04 b	36.27 ±1.07 b
SRI	3.77 ±0.57 a	7.00 ±0.48 a	25.63 ±1.04 a	31.00 ±1.58 a
The Line of Judgement	8.90 ±1.00 b	13.69 ±1.70 b	32.46 ±0.47 b	37.52 ±0.53 b
Modified Legowo Line	8.13 ±0.99 b	13.17 ±2.30 b	32.50 ±1.27 b	38.56 ±1.42 b
BNJ 5%	2.11	3.25	4.12	3.62
Paclobutrazol Concentration (ppm)				
0	7.06 ±2.42	11.42 ±3.18	30.17 ±3.18	35.85 ±3.45
600	7.23 ±2.4	11.65 ±3.53	30.17 ±3.32	35.83 ±3.27
700	7.44 ±2.32	11.60 ±3	30.42 ±3.12	36.08 ±3.32
800	7.04 ±2.14	11.21 ±3.04	30.04 ±3.21	35.67 ±3.12
BNJ 5%	tn	tn	tn	tn

Description: Numbers followed by the same letter in the same column and treatment show no significant difference in the 5% BNJ test; tn = not significant.

Table 3. Average Number of Rice Tillers Aged 7 – 28 HST in Planting System and Paclobutrazol Concentration Treatments

Treatment	Number of Offspring		
	14 HST	**21 HST**	**28 HST**
Planting System			
Traditional	5.15±1.09 ab	12.23±1.45 b	16.71±0.57 b
SRI	3.54±0.36 a	8.25±0.47 a	12.13±0.54 a
The Line of Judgement	6.67±0.38 b	16.15±0.41 c	22.04±0.43 c
Modified Legowo Line	7.98±0.12 b	18.54±0.38 c	24.69±1.60 d
BNJ 5%	1.93	2.58	2.61
Paclobutrazol Concentration (ppm)			
0	5.79±1.91	13.81±4.12	18.96±5.14
600	5.77±1.88	13.69±4.21	18.85±5.11
700	5.88±1.83	13.67±4.18	18.88±4.98
800	5.90±1.71	13.90±4.18	18.88±5.33
BNJ 5%	tn	tn	tn

Description: Numbers followed by the same letter in the same column and treatment show no significant difference in the 5% BNJ test; tn = not substantial.

These results are in line with the findings of Rombon et al. (2019), which reported that Paclobutrazol application tends to suppress plant height growth but does not significantly affect the number of leaves. The physiological justification lies in the mechanism of action of Paclobutrazol, a retardant that inhibits the biosynthesis of gibberellin hormones, which play a significant role in cell elongation. Because leaf formation is more controlled by meristem and cytokinin activity, not gibberellin, Paclobutrazol application does not have a direct impact on the number of leaves. In other words, the effect of Paclobutrazol is more structural on stem morphology, not on leaf quantity, as long as there is no environmental stress or other hormonal imbalance.

3.4. Flower Appearance Age

The results of the analysis of variance showed that the combination of various planting systems with paclobutrazol concentrations did not show a significant interaction with the age of rice flower emergence. The average age of rice flower emergence affected by planting system treatments and paclobutrazol concentrations is presented in Table 4.

Table 4. Shows that the emergence of flowers in rice plants does not show a significant effect due to the interaction between the planting system and Paclobutrazol concentration. However, treatment with Paclobutrazol at a

concentration of 600–800 ppm tends to accelerate the time of flower emergence compared to the control. This result indicates that Paclobutrazol can accelerate the transition from the vegetative phase to the generative phase by inhibiting gibberellin biosynthesis, thereby supporting earlier flowering (Fauziah et al., 2024).

These results align with the research of Lutfiana et al. (2023), which reported that Paclobutrazol can accelerate panicle formation and increase yields. In this study, a concentration of 600 ppm was proven to be effective in increasing the number of panicles and seed weight, especially in the modified Legowo planting system. Physiologically, gibberellin inhibition causes a shift in plant energy allocation from vegetative growth to the formation of generative organs, thereby supporting flowering synchronization and increasing productivity.

Table 4. Average Age of Rice Flower Emergence in Planting System and Paclobutrazol Concentration Treatments

Treatment	Flowering Age (days)
Planting System	
Traditional	57.96±1.10
SRI	58.21±1.44
The Line of Judgement	58.13±1.28
Modified Legowo Line	58.06±1.29
BNJ 5%	tn
Paclobutrazol Concentration (ppm)	
0	60.13±0.65 b
600	57.21±0.27 a
700	57.58±0.19 a
800	57.44±0.15 a
BNJ 5%	0.46

Description: Numbers followed by the same letter in the same column and treatment show no significant difference in the 5% BNJ test; tn = not substantial.

3.5. Length of Panicle Per Clump

The results of the analysis of variance showed that the combination of treatments between various planting systems and paclobutrazol concentrations resulted in a highly significant interaction on the length of panicles per hill in rice plants (*Oryza sativa* L.). The average length of rice panicles per hill in the combination of planting system treatments and paclobutrazol concentrations is presented in Table 5.

Table 5. Average Length of Rice Panicle per Hill in Combination of System Treatments Planting and Concentration of Paclobutrazol

Paclobutrazol Concentration (ppm)	Panicle Length per Clump (cm)			
	Planting System			
	Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
0	19.13±0.81 b	18.17±3.26 ab	19.88±2.06 b	20.75±2.41 b
600	18.96±1.09 b	18.92±1.87 b	15.67±1.46 ab	15.83±1.37 ab
700	18.33±1.42 ab	17.06±1.09 ab	16.33±2.02 ab	20.00±3.13 b
800	15.50±0.57 a	18.00±1.37 ab	17.58±1.25 ab	15.88±0.57 ab
BNJ 5%	3.31			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

Table 5 shows that the panicle length per clump increased in the modified Legowo planting system treatment, especially when combined with 600 ppm Paclobutrazol. The open planting pattern increases light penetration and air circulation, supporting more optimal panicle development. Paclobutrazol helps channel photosynthesis results to generative organs, resulting in longer panicles (Tambajong et al., 2016).

3.6. Number of Panicles Per Clump

The results of the analysis of variance showed that the combination of various planting systems with different concentrations of paclobutrazol had a significant effect on the number of panicles per clump of rice plants (*Oryza sativa* L.). The average number of panicles per clump of rice plants resulting from various planting systems treated with paclobutrazol concentrations is presented in Table 6.

Table 6 shows a significant increase in the number of panicles per hill in the modified jajar Legowo planting system treatment, especially when combined with 600 ppm Paclobutrazol. The more open Jajar Legowo planting system increases light penetration and air circulation, allowing for more optimal photosynthesis activity and assimilate distribution. Physiologically, this condition supports the formation of generative organs such as panicles. The administration of Paclobutrazol at moderate doses also enhances this effect by suppressing vegetative growth through the inhibition of gibberellin biosynthesis, thereby diverting more photosynthesis results to panicle development. This finding aligns with Maulidi et al. (2024) and Tambajong et al. (2016), who stated that the combination of intensive planting patterns and Paclobutrazol applications can significantly increase the number of panicles. Thus, the integration between planting pattern design and hormonal regulation through Paclobutrazol has proven effective in directing growth toward the generative phase and supporting increased rice yields.

Table 6. Average Number of Rice Panicles per Hill in Combination of Planting System Treatment and Paclobutrazol Concentration

Paclobutrazol Concentration (ppm)	**Number of Panicles per Clump**			
	Planting System			
	Traditional	**SRI**	**Jarwo (2:1)**	**Jarwo Modified (2:1)**
0	16.42±1.01 b	16.00±0.43 b	15.33±0.62 b	11.33±0.94 a
600	15.67±0.28 b	17.83±1.60 b	13.25±2.41 ab	13.08±1.04 ab
700	15.92±1.04 b	12.67±0.94 ab	11.25±0.66 a	12.92±0.80 ab
800	13.92±0.38 ab	13.42±1.62 ab	16.00±1 b	14.08±0.72 ab
BNJ 5%	3.24			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

3.7. Number of Seeds Per Panicle Per Clump

The results of the analysis of variance showed that the combination of various planting systems with different paclobutrazol concentrations had a significant effect on the number of seeds per panicle per clump in rice plants (*Oryza sativa* L.). The average number of seeds per panicle per clump of rice plants affected by various planting systems treated with paclobutrazol concentrations is presented in Table 7.

Table 7. Average Number of Rice Seeds per Panicle per Hill in Combination of Planting System Treatment and Paclobutrazol Concentration

Paclobutrazol Concentration (ppm)	**Number of Seeds per Panicle per Clump**			
	Planting System			
	Traditional	**SRI**	**Jarwo (2:1)**	**Jarwo Modified (2:1)**
0	142.30±1.93 cd	139.04±6.92 cd	121.69±3.68 bc	115.94±1.52 b
600	126.62±3.45 c	150.46±4.91 e	99.44±2.52 ab	120.71±5.05 bc
700	115.53±1.36 bc	114.29±3.25 b	122.64±1.76 ab	132.46±7.12 d
800	133.59±3.25 cd	121.78±2.51 bc	118.13±0.83 b	91.58±3.18 a
BNJ 5%	14.66			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

Table 7 shows that a planting system that supports optimal root growth, such as the SRI method, can increase seed formation per panicle. This increase is reinforced by the provision of Paclobutrazol in the correct concentration, which suppresses vegetative growth and redirects energy allocation to the formation of reproductive organs, such as panicles and seeds. These results are in line with research by (2019), which explains that Paclobutrazol inhibits gibberellin synthesis, causing plants to become more compact and resulting in photosynthesis that is more focused on filling seeds. Physiologically, a planting system such as SRI encourages the development of broader and deeper roots, thereby increasing water and nutrient absorption, which supports photosynthesis efficiency and seed formation. The combination of a planting system that supports root absorption and growth hormone regulation through retardants has proven effective in significantly increasing the number of seeds per panicle.

3.8. Seed Weight Per Clump

The results of the analysis of variance showed that the combination of various planting systems with different paclobutrazol concentrations had a significant effect on the number of seeds per panicle in rice plants (*Oryza sativa* L.). The average number of seeds per panicle per clump of rice plants based on the treatment of various planting systems with paclobutrazol concentrations is presented in Table 8.

Table 8 shows that the modified Legowo planting system combined with Paclobutrazol produces the highest seed weight per hill. Paclobutrazol suppresses gibberellin synthesis, inhibits excessive vegetative growth, and diverts energy to the generative phase. These results are in line with those of Lutfiana et al. (2023), who state that Paclobutrazol increases grain weight as an indicator of yield. (2016) also found that the combination of the Legowo planting system and Paclobutrazol significantly increased the weight of 1,000 grains and grain yield. Physiologically, the optimal planting layout and growth hormone regulation support efficient grain filling, thereby increasing seed weight per hill.

3.9. Seed Weight Per Plot

The results of the analysis of variance showed that the combination of planting system treatment and paclobutrazol concentration had a significant effect on seed weight per plot in rice plants (*Oryza sativa* L.). The average seed weight per plot in rice plants for the combination of planting system treatment and paclobutrazol concentration is presented in Table 9.

Table 8. Average Number of Seeds per Clump of Rice in Combination of Planting System Treatment and Paclobutrazol Concentration

Paclobutrazol Concentration (ppm)	Number of Seeds per Clump			
	Planting System			
	Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
0	2336.67±140.71 bc	2224.75±541.48 bc	1865.58±343.86 ab	1313.67±260.83 a
600	1984.17±96.31 b	2682.83±2802.22 c	1317.58±2252.29 a	1578.92±2006.93 ab
700	1839.25±111.16 ab	1448.08±2882.52 ab	1379.75±2251.67 ab	1711.50±11653.31 ab
800	1859.67±194.13 ab	1634.33±2906.32 ab	1890.08±2216.23 ab	1289.50±10927.6 a
BNJ 5%	607.18			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

Table 9. Average Weight of Rice Seeds per Plot in Combination of Planting System Treatment and Paclobutrazol Concentration

Paclobutrazol Concentration (ppm)	Seed Weight per Plot (kg/5m ^{2})			
	Planting System			
	Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
0	3.03±0.16 b	2.88±0.23 ab	3.43±0.20 c	2.57±0.05 a
600	3.35±0.05 bc	3.45±0.05 c	4.02±0.07 d	2.85±0.05 ab
700	3.45±0.05 c	3.38±0.05 c	3.90±0.1 d	2.72±0.02 ab
800	3.37±0.12 c	3.43±0.07 c	3.78±0.12 d	2.70±0.08 a
BNJ 5%	0.33			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

Table 9 shows that the Legowo planting system yielded the highest seed weight per plot when combined with Paclobutrazol. A more open planting layout improves light distribution, air circulation, and the effect of edge plants, thus encouraging individual productivity in the plot. Paclobutrazol, as an inhibitor of gibberellin biosynthesis, suppresses vegetative growth and directs plant metabolic energy to the generative phase (Silitonga & Nasution, 2019). The combination of the two enhances photosynthesis efficiency, promotes productive tillering, and facilitates seed filling. These results are supported by Tambajong et al. (2016), which states that the application of Paclobutrazol increases leaf chlorophyll content, allowing the photosynthesis process to take place more efficiently and directly impacting physiologically. The interaction between efficient planting architecture and internal hormonal regulation through retardants creates optimal conditions for maximum seed formation and filling.

3.10. Seed Weight Per Hectare

The results of the analysis of variance showed that the combination of treatments of various planting systems with paclobutrazol concentrations provided a significant interaction on seed weight per hectare in rice plants (*Oryza sativa* L.). The average seed weight per hectare in rice plants resulting from the combination of various planting systems and paclobutrazol concentrations is presented in Table 10.

Table 10. Average Weight of Rice Seeds per Hectare in Combination of Planting System Treatment and Paclobutrazol Concentration

Paclobutrazol Concentration (ppm)	Seed Weight per Hectare (ton/ha)			
	Planting System			
	Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
0	6.07±0.32 b	5.77±0.46 ab	6.87±0.41 c	5.13±0.11 a
600	6.70±0.1 bc	6.90±0.1 c	8.03±0.15 d	5.70±0.1 ab
700	6.90±0.1 c	6.77±0.11 c	7.80±0.2 d	5.43±0.05 ab
800	6.73±0.25 c	6.87±0.15 c	7.57±0.25 d	5.40±0.17 a
BNJ 5%	0.66			

Description: Numbers followed by the same letter in the treatment combination show no significant difference in the 5% BNJ test.

Table 10 shows that the Legowo planting system is capable of increasing light intensity and air circulation, thereby allowing the photosynthesis process to occur more optimally. This photosynthesis efficiency has a direct impact on increasing the weight of dry grain per hectare. Paclobutrazol, a growth regulator from the retardant group, inhibits gibberellin synthesis, thereby suppressing vegetative growth and redirecting energy allocation toward seed formation (Silitonga & Nasution, 2019). The combination of systems

open planting with the administration of Paclobutrazol at the correct dose encourages resource allocation to the generative phase. These results align with the findings of Rombon et al. (2019), who reported that Paclobutrazol at 600 ppm significantly increased the weight of dry-milled grain. Physiologically, this condition reflects the synergy between an efficient canopy structure and internal hormonal regulation, which overall supports increased land productivity.

3.11. Chlorophyll Analysis

Laboratory test results showed that the combination of traditional planting systems with a paclobutrazol concentration of 800 ppm yielded the lowest chlorophyll content. In contrast, the combination of the SRI planting system with a paclobutrazol concentration of 700 ppm resulted in the highest chlorophyll content. Complete data on the results of leaf chlorophyll content testing are presented in Table 11.

Table 11. Results of Total Chlorophyll Analysis

Paclobutrazol Concentration (ppm)	**Total Chlorophyll (mg/L)**			
	Planting System			
	Traditional	SRI	Jarwo (2:1)	Jarwo Modified (2:1)
0	19.06	18.45	18.75	18.14
600	19.22	18.89	17.30	17.66
700	18.42	14.87	17.83	18.19
800	19.42	16.41	16.91	17.80

Note: Calculation using the Harborne 1987 method, Unit (mg/L)

Table 11. Shows that Paclobutrazol, as a plant growth regulator, affects the increase in chlorophyll content of rice plants. The mechanism of action involves suppressing the synthesis of gibberellin hormones and increasing the synthesis of abscisic acid hormones, as well as enhancing leaf chlorophyll. As a result, plants have thicker leaves, smaller stomatal pores, and higher chlorophyll density, which can ultimately improve photosynthesis efficiency (Desta and Amare, 2021). Paclobutrazol also plays a role in extending the functional life of leaves by slowing down the aging process, which contributes to an increase in total chlorophyll content. This result is reinforced by the findings of Fauziah et al. (2024), which stated that a paclobutrazol concentration of 600 ppm gave the highest chlorophyll content compared to other concentrations. This high chlorophyll content is in line with the increase in overall rice plant productivity.

Figure 2. Results of Chlorophyll Analysis

4. Conclusion

This study demonstrates that the combination of planting system and Paclobutrazol concentration has a significant impact on the growth and yield of rice. The modified jajar Legowo planting system with 600 ppm Paclobutrazol produces the most efficient development and the highest production. These results suggest that the arrangement of the planting system and the application of ZPT can optimize rice productivity sustainably.

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