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Influence of ABC Mix and Gibberellin on Growth and Yield of Red Rice under Soilless Cultivation

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Abstract:
The use of AB Mix as a nutrient in soilless paddy cultivation actually prolongs the vegetative phase, which results in delayed flowering. This study aims to analyze the effects of gibberellin concentration and ABC Mix (AB Mix + silica) on flowering age, growth, and production yield of red paddy. The experiment was designed using a split plot arrangement within a completely randomized design involving 2 factors and 3 replications. The first factor was gibberellin concentration (sub plot) consisting of 2 treatments: control and 200 ppm. The second factor was ABC Mix nutrient concentration (main plot) consisting of 4 treatments: EC 750–800 ppm, EC 1,000–1,050 ppm, EC 1,250–1,300 ppm, and EC 1,500–1,550 ppm. The results showed that the ABC Mix treatment at EC 750–800 ppm combined with GA3 at 200 ppm significantly affected plant height (192.0 cm). Additionally, the GA3 200 ppm treatment also significantly influenced grain weight per clump (39.03 grams) and plant height. Meanwhile, the ABC Mix EC 750–800 ppm treatment showed significant differences in total tiller number (60.03 stalks), number of productive tillers (23.03 stalks), panicle length (55.42 cm), 1,000 grain weight (24.84 grams), and plant height. ABC Mix nutrients contain a complete and balanced composition of essential elements, enabling them to meet the growth requirements of rice plants during both the vegetative and reproductive phases, leading to more optimal production. Meanwhile, flowering age in all treatments exceeded 80 days after transplanting (DAT). This is presumed to be due to a delay in the application of GA3, as the activation of floral meristem genes requires approximately five days after GA3 is applied. Additionally, GA3 plays a role in cell elongation, which affects plant height and may contribute to delayed initiation of flowering.

Keywords:
ABC mix, GA3, red paddy, soilless

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INTRODUCTION

Red rice contains anthocyanins that function as antioxidants, which are absent in white rice (Sugiarto et al., 2018). Red rice has great potential as a primary source of carbohydrates and also contains protein, beta-carotene, and iron (Harmawati et al., 2023). With its high nutritional content, red rice has the potential for development, one of which is through soilless cultivation methods. The development of red rice using soilless cultivation will not interfere with white rice production. To achieve red rice productivity, the soilless system does not require extensive land, making it suitable for urban areas with limited space compared to traditional paddy field cultivation.

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Generally, soilless cultivation uses AB mix nutrients. However, previous studies showed that using AB mix yielded suboptimal results and delayed the flowering phase. This is likely due to an inappropriate nutrient composition. According to Susanti (2022), the delay in flowering in rice plants cultivated soillessly is caused by nutrient management that does not align with the plants' needs. One solution to address this problem is to add silica to the AB mix solution and to use plant growth regulators (PGRs). The application of silica can influence plant growth, especially when combined with other nutrient sources containing balanced macro- and micronutrients.

The use of silica is based on its ability to strengthen plant stem structure, reduce stress caused by biotic and abiotic factors, and provide protection against pest and disease attacks (Rahmayuni et al., 2024). Meanwhile, Plant Growth Regulators are non-nutrient organic compounds that are active in small amounts and synthesized in specific parts of the plant (Irvan & Adriana, 2017). One type of plant growth regulator used is the gibberellin hormone, which functions to stimulate the flowering process. Therefore, the combination of AB Mix nutrients with silica (ABC Mix) and the addition of plant growth regulators is expected to produce a balanced and suitable nutrient formula for the growth of red rice in this study.

METHOD

This research was conducted from July 2024 until completion in a greenhouse located in Sumber Jeruk Village, Kalisat District, Jember Regency, East Java (coordinates 8°07'42.9" S and 113°47'09.3" E) at an altitude of 281 meters above sea level. The average daily temperature ranged from 21°C to 30°C, with an average daily humidity of 65% to 75%.

The experimental design used was a Split Plot based on a Factorial Completely Randomized Design (FCRD) with 2 factors and 3 replications. GA3, the first factor, had 2 treatment levels: G0 = 0 ppm and G1 = 200 ppm. Meanwhile, ABC Mix, the second factor, consisted of 4 treatment levels: P1 = EC 750–800 ppm, P2 = EC 1000–1050 ppm, P3 = EC 1250–1300 ppm, and P4 = EC 1500–1550 ppm.

The plant growth regulators were applied in the morning by hand-spraying at 57, 59, and 61 days after transplanting (DAT). The collected data were analyzed using Analysis of Variance (ANOVA). If significant results were found, further tests were conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level for significant differences and at a 1% significance level for highly significant differences.

RESULT

Based on the results of the study, the observed variables, including plant height, number of productive tillers, flowering age, panicle length, weight of filled grain per clump, weight of unfilled grain per clump, and 1000 grain weight, were analyzed using ANOVA, with notation provided for each observed variable. The summary of the analysis of variance results is presented in Table 1-6.

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Table 1. Summary of analysis of variance results for all observed variables

Observed Variable	F-value		
	GA3 (G)	ABC Mix (P)	Interaction (G X P)
Plant Height	59.44**	68.55**	27.99**
Number of Productive Tillers	4.86ns	4.72*	2.38ns
Flowering Age	2.52ns	0.74ns	0.07ns
Panicle Length	0.01ns	4.30*	2.97ns
Filled Grain Weight per Clump	12.58*	1.13ns	1.76ns
Unfilled Grain Weight per Clump	0.42ns	0.54ns	1.14ns
1000 Grain Weight	3.55ns	9.40**	1.60ns

Note: Notation indicates non-significant difference (ns), significant difference (*), and highly significant difference (**)

Plant Height

Table 2. Red Paddy Plant Height During the Vegetative and Generative Phases

GA3 (ppm)	ABC Mix (ppm)			
	750-800	1,000-1,050	1,250-1,300	1,500-1,550
0	82.00 b B	88.00 b A	75.08 b B	84.07 b B
200	192.00 a A	191.04 a AB	150.01 a B	183.06 a B

Note: Values followed by the same lowercase letter in the same column and numbers followed by the same uppercase letter in the same row indicate no significant difference based on the DMRT 1%.

The plant height variable during the vegetative phase did not show statistically significant differences under either single or combined treatments. Based on observations, the highest average plant height was recorded in the treatment without GA3 at 200 ppm and with an EC of 1000–1050 ppm, reaching 88 cm. Meanwhile, the lowest average plant height was observed in the treatment without GA3 and with an EC of 1250–1300 ppm, at 75,8 cm.

In contrast, during the generative phase, an interaction between ABC Mix and GA3 was observed. The highest result in the treatment without GA3 using ABC Mix at an EC of 1000–1050 ppm reached an average plant height of 88 cm. In comparison, the treatment with GA3 at 200 ppm and an EC of 750–800 ppm resulted in an average plant height of 192,00 cm.

Number of Productive Tillers

Table 3. Number of Productive Tillers of Red Paddy

ABC Mix Concentration (ppm)	Number of Productive Tillers (stalks)
750-800	23.03 a
1,000-1,050	17.00 b
1,250-1,300	18.02 ab
1,500-1,550	21.83 ab

Note: Values followed by the same letter indicate no significant difference according to the DMRT at 5% level.

The variable for the number of productive tillers showed that the ABC Mix treatment with an EC of 750–800 ppm resulted in the highest average number of productive tillers, at 23.03 stalks. This result was not statistically significantly different from the treatment with EC 1250–1300 ppm, which produced 18.02 stalks, and the treatment with EC 1500–1550 ppm, which produced 21.83 stalks.

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Flowering Age

The flowering age variable did not show statistically significant differences under either single or combined treatments. Observational results indicated that the longest flowering age occurred in the GA3 treatment at 200 ppm and the EC 1500–1550 ppm, reaching 84 days after transplanting (DAT). Conversely, the earliest flowering age was recorded in the treatment without GA3 and with EC 750–800 ppm, at 75 days after transplanting (DAT).

Panicle Length

Table 4. Panicle Length of Red Paddy

ABC Mix Concentration (ppm)	Panicle Length (cm)
750-800	55.42 a
1,000-1,050	47.17 b
1,250-1,300	49.42 ab
1,500-1,550	49.05 ab

Note: Values followed by the same letter indicate no significant difference according to the DMRT at 5% level.

The panicle length variable showed that the ABC Mix treatment with an EC of 750–800 ppm had the highest average panicle length, at 55.42 cm. This result was not statistically significantly different from the treatment with EC 1250–1300 ppm, which reached 49.42 cm, and the treatment with EC 1500–1550 ppm, which reached 49.05 cm.

Filled Grain Weight per Clump

Table 5. Filled Grain Weight per Clump Red Paddy

ABC Mix Concentration (ppm)	Filled Grain Weight per Clump (grams)
0	39.03 a
200	13.01 a

Note: Values followed by the same letter indicate no significant difference according to the DMRT at 5% level.

The variable of filled grain weight per clump showed that the treatment without GA3 application had the highest average, at 39.03 grams. This result was not significantly different from the 200 ppm GA3 treatment, which reached 13.01 grams. The more efficient treatment was without GA3 application, as it yielded higher yields.

Unfilled Grain Weight per Clump

The variable of unfilled grain weight per clump showed no significant differences between single and combined treatments. The highest average unfilled grain weight per clump was observed in the treatment with 0 ppm GA3 and an EC of 1250–1300 ppm, at 1,3 grams, while the lowest average was found in the treatment with 200 ppm GA3 and an EC of 1,000–1,050 ppm, at 1,1 grams.

1,000 Grain Weight

The 1,000-grain weight variable showed the highest value in the ABC Mix treatment with an EC of 1,500–1,550 ppm, at 24.84 grams. This result was not statistically significantly different from the treatment with EC 700–800 ppm, which reached 21.85 grams, and the treatment with EC 1,000–1,050 ppm, which reached 22.32 grams.

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Table 6. 1,000 Grain Weight Red Paddy

ABC Mix Concentration (ppm)	1,000 Grain Weight (grams)
750-800	21.85 ab
1,000-1,050	22.32 ab
1,250-1,300	20.47 b
1,500-1,550	24.84 a

Note: Values followed by the same letter indicate no significant difference according to the DMRT at 1% level.

DISCUSSION

In the vegetative phase, neither single nor combined treatments had a significant effect on plant height. This is presumed to be due to the use of ABC Mix nutrients, which provide a complete and balanced composition of macro- and micronutrients, thereby meeting the growth requirements of rice plants during the vegetative phase (Anggreani, 2024). Meanwhile, during the generative phase, a more rapid increase in plant height was observed following GA3 application. This condition is estimated to result from GA3's influence. This statement aligns with the opinion of Irvan and Adriana (2017), who stated that the application of GA3 can accelerate stem elongation and increase plant height.

According to Widodo and Damanhuri (2021), the number of productive tillers is proportional to the total number of tillers formed. Suraida (2024) stated that silica can stimulate plant growth, as indicated by an increase in plant height and a greater number of tillers. This is in line with the statement by Sabatini et al. (2017), who noted that the presence of silica can influence the tiller-formation process through cell division. The application of silica can increase the number of tillers and panicles in rice plants, as each tiller contributes to the formation of one panicle (Subiksa, 2018). This statement is supported by Malav et al. (2016), who reported that silica nutrient application can increase rice panicle size. Panicle length itself affects grain weight per clump, as it shows a positive correlation with grain weight per panicle. Therefore, the use of the ABC Mix treatment has the potential to increase crop productivity.

In the generative phase, gibberellins play a crucial role in accelerating flowering, which affects both yield and harvest quality. Typically, rice plants begin to flower at around 65 days after transplanting (DAT), but in this study, flowering occurred at 80–85 days after transplanting (DAT). This delay is presumed to be caused by the untimely application of GA3, whereas activation of floral meristem genes generally occurs about five days after GA3 is administered. Safira (2021) explained that GA3 triggers the flowering process by activating floral meristem genes. Delayed GA3 application prolongs the vegetative phase, increasing plant height but delaying the onset of flowering. This is consistent with the opinion of Susilawati et al. (2014), who stated that GA3 actively influences cell elongation and division processes, thereby affecting plant height growth.

The variable of unfilled grain weight did not show a significant effect under either single or combined treatments. According to Suyani et al. (2017), the number of unfilled grains is influenced by the photosynthetic output of the leaves and the distribution of photosynthates from other parts of the plant. The increase in filled grain weight per clump is presumed to be associated with GA3 application. Yusanti et al. (2017) reported that GA3 application can enhance chlorophyll content in plants, thereby accelerating photosynthesis and contributing to increased grain weight. However, treatments without GA3 resulted in the highest average grain weight per clump, suggesting that improved yields can still be achieved more efficiently even without GA3 application. The increase in 1,000-grain weight is presumed to be due to the addition of silica to the ABC Mix nutrient. This aligns

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with the opinion of Rao et al. (2017), who stated that although silica is not an essential nutrient, its presence can increase rice 1,000-grain weight.

CONCLUSION

The ABC Mix treatment with an EC of 750–800 ppm and GA3 at 200 ppm significantly increased plant height. The GA3 treatment at 200 ppm significantly affected plant height and the weight of filled grain per clump. Meanwhile, the ABC Mix treatment with an EC of 750–800 ppm had a significant effect on plant height, the number of productive tillers, panicle length, and 1000 grain weight. It is recommended that the GA3 application be carried out earlier, specifically at 45, 47, and 49 days after transplanting (DAT), to optimize the activation of genes that trigger the expression of genes responsible for flower organ formation.

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