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Growth and Yield Response of Functional Rice through ABC Mix Nutrition Supply

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Abstract:
Grain filling is not ideal when AB Mix is used as a rice fertilizer in a soilless culture method because it causes a lengthy vegetative phase and a brief generative phase. The purpose of this study is to investigate the use of ABC Mix (AB Mix + Silica) to two functional rice varieties: Black Madrass and A2 Variety. A factorial Completely Randomized Design (CRD) including two factors and three replications, was used on the experimental design. The ABC Mix nutritional content (750-800 ppm, 1000-1050 ppm, 1250-1300 ppm, and 1500-1550 ppm) is the first factor, while the type of functional rice (black rice variety Black Madras and red rice variety A2) is the second. The results showed that the use of ABC mix 1000-1050 ppm on A2 red rice had a significant effect on the number of productive tillers (29.67 stems). The application of 1500-1550 ppm ABC mix showed a significant effect on the weight of 1000 grains (27.55 g), while the A2 red rice variety showed better performance based on plant height (86.64 cm). The silica content in ABC mix nutrients plays a role in strengthening plant tissue and increasing the efficiency of nutrient absorption so that it is directly able to increase the growth and yield of rice in the soilless culture system.

Keywords:
ABC Mix, functional rice, soilless culture

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INTRODUCTION

Beras Rice is the world's staple food, with total national production in Indonesia reaching 54.75 million tons of milled dry rice in 2023 and 53.98 million tons in 2024 (Central Statistics Agency, 2023). The decline in rice production in Indonesia is due to reduced agricultural land resulting from land conversion for non-agricultural uses. Population growth triggers the conversion of agricultural land into non-agricultural areas such as housing, office buildings, and shopping centers. Soilless rice cultivation is an effective alternative to address land limitations. Growing plants with soilless media is almost the same as growing media in hydroponics. However, the difference between hydroponics and soilless cultivation is that hydroponics uses a growing medium without soil, whereas soilless cultivation minimizes soil use in plant cultivation. Not many people are aware of information on rice cultivation using soilless media, and only a few have researched it as a growing medium. Therefore, there is a need for research on rice cultivation using soilless media.

Functional rice is a staple food with high nutritional content that is beneficial for health. In the cultivation of functional rice using a soilless culture system, nutrient supplementation is essential to ensure the plants receive sufficient nutrients. Based on previous research, the nutrients used include AB Mix (fertilizer A and fertilizer B). AB mix nutrition contains macro- and micro-nutrients that are

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essential for supporting plant growth and yield. These nutrients consist of several chemical elements necessary for plant growth (Hidayati et al., 2019). ABC mix nutrition is a combination of AB mix nutrition and silica fertilizer. The application of silica fertilizer can increase the silica and lignin content in plant organs. The increased silica and lignin content in plant organs is associated with cell wall components that provide physical strength, allowing plants to remain upright even under flooding or drought stress (Apriliyanto, 2020).

A problem in previous research that has not been resolved is the use of AB Mix nutrients as rice nutrients in soilless culture systems, which prolongs the vegetative phase. Meanwhile, the generative phase shortens, leading to suboptimal seed filling. This study aims to examine the use of ABC Mix (AB Mix + Silica) on two functional rice varieties (red rice variety A2 and black rice variety black madrass). Therefore, it is necessary to provide ABC Mix nutrients to improve growth and yield in the functional rice variety Red A2 and the black rice variety Black Madras.

METHOD

The research was conducted from July 2024 until completion in a greenhouse in Sumber Jeruk Village, Kalisat District, Jember Regency, East Java (coordinates 8° 07'42.9" S and 113° 47'09.3" E; altitude 281 meters above sea level; air temperature 21°C – 30°C; humidity 65% – 75%). The tools used were planting tubs measuring 60 cm x 40 cm x 20 cm, a ruler, scissors, a cutter, label paper, a bucket, an EC meter, a pH meter, net pots, measuring cups, hand sprayers, and an analytical scale. The materials used included A2 red rice seeds, water, rice husk, topsoil, gravel, ABC nutrient mix, pesticides, pH down, and GA3 growth regulators.

The experimental design is a Split-Plot based on a Completely Randomized Factorial Design (CRFD) with 2 factors and 3 replications. The concentration of ABC mix as the first factor consists of 4 treatment levels: P1: 750-800 ppm ≈ 1.5 mS/cm - 1.6 mS/cm, P2: 1000-1050 ppm ≈ 2 mS/cm - 2.1 mS/cm, P3: 1250-1300 ppm ≈ 2.5 mS/cm - 2.6 mS/cm, P4: 1500-1550 ppm ≈ 3 mS/cm - 3.1 mS/cm. The second factor consists of 2 varieties of functional rice: V1: Red rice variety A2; V2: Black rice variety Black Madras. The application of ABC Mix nutrients is done by first preparing a stock solution of nutrients A and B in a 1:1 ratio, dissolved in 5 liters of water. For stock nutrient solution C, 138 mL is dissolved in 2 liters of water. Dissolving nutrients into 100 liters of raw water means using 80 liters of raw water to prepare solution AB, with nutrient solution A at 500 ml and nutrient solution B at 500 ml. Meanwhile, 80 liters of raw water are used to prepare nutrient solution C at 500 ml, which is then checked for pH. Then it is checked using a TDS or EC meter. The water and nutrient ABC mix medium does not need to be replaced, but it should be checked every 3 days. Nutrient application is carried out every 3 days in the morning or evening by dissolving the nutrients in the planting container. If the EC value is too high, raw water is added. If the EC value decreases, the nutrient ABC mix is added.

The collected data were analyzed using Analysis of Variance (ANOVA). When a significant effect was detected, a post hoc analysis was performed using Duncan's Multiple Range Test (DMRT), with significance set at 5% for significant differences and 1% for highly significant differences.

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RESULT

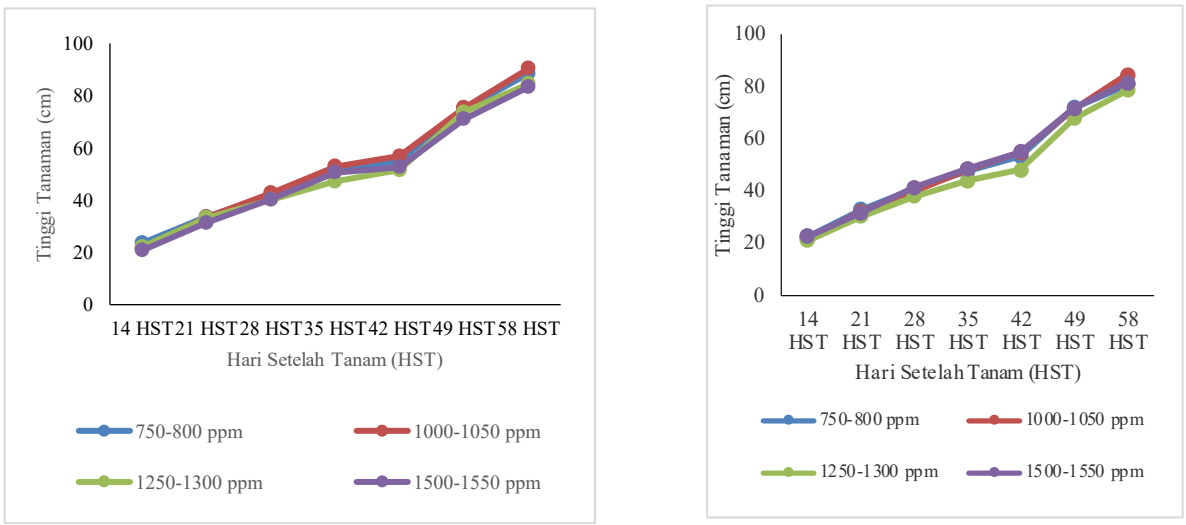
Plant Height

Table 1. Height of rice plants under each treatment of ABC Mix and GA3

Variety	Average Plant Height (cm)
Red A2	86.64 a
Black Madras	81.22 b

Note: Numbers followed by different letters indicate a significant difference in the BNT 5% further test.

Based on Table 1, the best treatment for the plant height observation variable is the red rice variety A2, with an average of 86.64 cm. Meanwhile, the black rice variety Black Madrass averages 81.22 cm.



(A) (B)

Figure 1. Growth of Red Rice Plant Varietas A2 (A) and Black Rice Varietas Black Madrass (B)

Based on the graph of plant growth rate, all ABC Mix nutrient ratios in both varieties peaked at 58 days after sowing. Compared with the other variety, the red rice variety showed the greatest increase at 58 days after sowing.



(a) (b) (c) (d)

Figure 2. Plant Height (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1,000-1,050 ppm; (c) Red Rice variety A2+ ABC Mix 1,250-1,300 ppm; (d) Red Rice variety A2 + ABC Mix 1,500-1,550 ppm.

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(a) (b) (c) (d)

Figure 3. Plant Height (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1,000-1,050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1,250-1,300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1,500-1,550 ppm

Length of the Necklace

The length of the roots greatly affects the way they absorb water and nutrients needed for plant survival. Based on the Analysis of Variance results, the root length is not significantly different across treatments ("ns"), so further testing cannot be conducted. The root length can be supported by using a method that tests all levels of nutritional treatment.



(a) (b) (c) (d)

Figure 4. Length of the Necklace (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1,000-1,050 ppm; (c) Red Rice variety A2+ ABC Mix 1,250-1,300 ppm; (d) Red Rice variety A2 + ABC Mix 1,500-1,550 ppm



(a) (b) (c) (d)

Figure 5. Length of the Necklace (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1,000-1,050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1,250-1,300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1500-1,550 ppm

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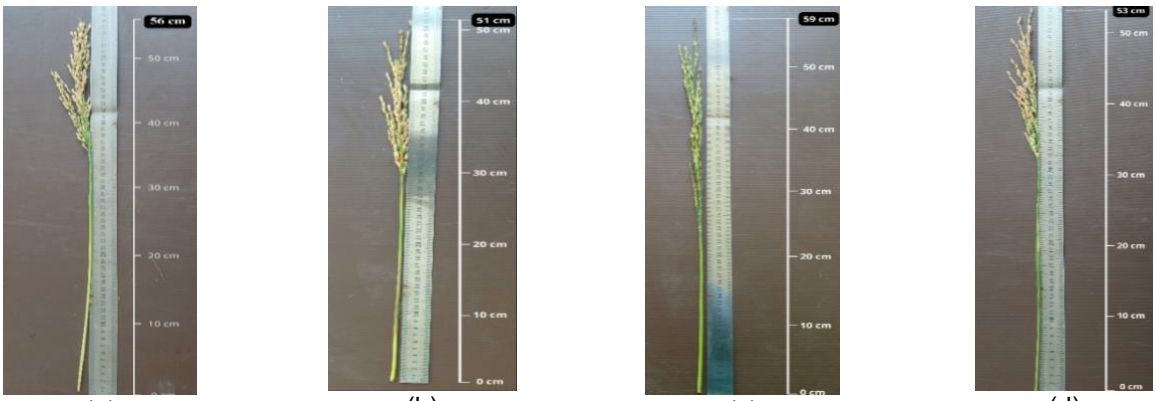
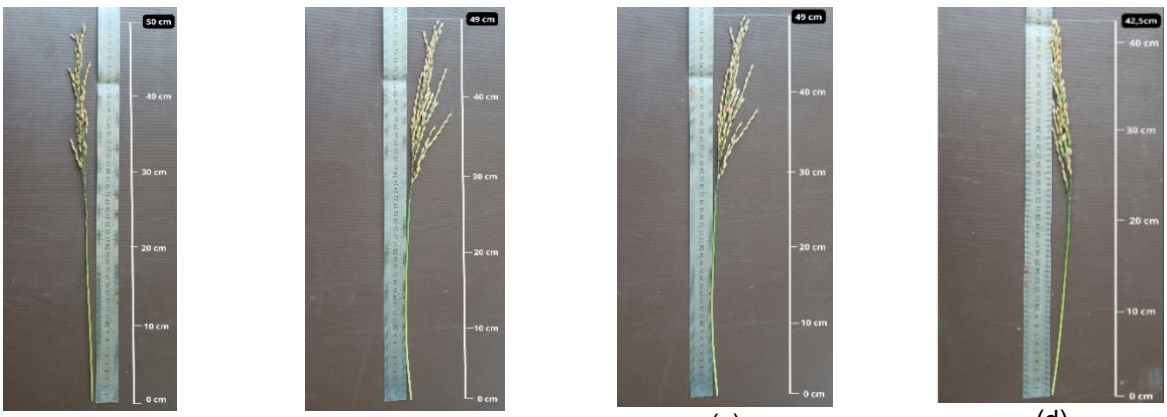
Panicle Length

The length of the rice panicle is one of the indicators of the number of grains it contains. Generally, the longer the panicle, the more grains it contains (Aziez, 2019). Based on the results of the Analysis of Variance, the length of the panicle showed a notation of not significantly different "ns" from the treatment, so further testing cannot be conducted. The panicle length can be supported by all tested nutrient levels.



(a) (b) (c) (d)

Figure 6. Panicle Length (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1000-1050 ppm; (c) Red Rice variety A2+ ABC Mix 1250-1300 ppm; (d) Red Rice variety A2 + ABC Mix 1500-1550 ppm



(a) (b) (c) (d)

Figure 7. Panicle Length (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1000-1050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1250-1300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1500-1550 ppm

3.3 Weight of 1000 grains

Table 2. Weight of 1000 grains of Red Rice A2 and Black Madrass Rice (grams) Concentration ABC Mix

Concentration of ABC Mix (ppm)	Weight of 1,000 grains (grams)	
	Red Rice A2	Black Rice Black Madrass
750-800	23.31 bc	22.41 c
1,000-1,050	20.90 c	21.45 c
1,250-1,300	21.47 c	23.60 bc
1,500-1,550	27.55 a	26.38 ab

Note: Numbers followed by the same letter indicate no significant difference in the BNT 5% further test.

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Based on Table 2, the best treatment for the observation variable of the weight of 1,000 grains is at the concentration of ABC mix in the red rice variety, with a concentration of 1,500-1,550, with an average of 27.55 grams. Meanwhile, it shows no significant difference compared to the 1,500-1,550-ppm concentration of the black madras variety, with an average of 26.38 grams.



(a) (b) (c) (d)

Figure 8. Weight of 1,000 grains (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1,000-1,050 ppm; (c) Red Rice variety A2+ ABC Mix 1,250-1,300 ppm; (d) Red Rice variety A2 + ABC Mix 1,500-1,550 ppm



(a) (b) (c) (d)

Figure 9. Weight of 1,000 grains (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1,000-1,050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1,250-1,300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1,500-1,550 ppm

Weight of Grain Per Panicle

Table 3 Weight of Grain Per Panicle of Red Rice A2 and Black Rice Black Madrass (grams)

Variety	Concentration of ABC Mix (ppm)			
	750-800	1,000-1,050	1,250-1,300	1,500-1,550
Merah A2	12.9 Aa	10.32 Ba	7 Cb	7.7 Cb
Black madras	5.12 Cb	10.71 Aa	8.8 Ba	10.79 Aa

Note: The numbers filled in with the same uppercase letters on the same row and the numbers filled with the same lowercase letters in the same column indicate results that are not significantly different based on the DMRT 5% follow-up test.

Table 3 shows that the best treatment interaction for the observed variable, empty grain weight, is for the A2 red rice variety and the ABC mix treatment at 750-800 ppm, with an average of 12.9 grams. However, it does not have a significant effect on the black madrass variety with ABC Mix concentrations of 1000-1050 ppm and 1500-1550 ppm. The number of empty grains in the plants used was not affected by the variety treatment or the interaction between the treatments (Abbas et al., 2018). This is suspected to be because the A2 red rice variety has better genetic traits for grain production than the black madrass rice variety (Yulina et al., 2020). Meanwhile, according to Ezward et al., (2020), red rice has more effective genes in regulating grain production. The application of silica can extend panicle length and increase grain yield. The difference in the percentage of filled

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grains is suspected to be due to genetic factors in each rice variety. The high percentage of filled grains per panicle is strongly influenced by the number of grains per panicle and nutrient availability. Suitable growing conditions tend to stimulate the initiation of perfect panicles, thereby increasing the likelihood of grain formation. However, the more grains that are formed, the greater the burden on the plant to produce filled grains. If the grain filling process is not accompanied by sufficient nutrient availability, a large number of empty grains will be formed. The percentage of filled grains is one of the indicators of crop productivity; the higher the percentage of filled grains obtained by a variety, the higher the productivity of the variety (Mahmud et al., 2014).



(a) (b) (c) (d)

Figure 10. Weight of Grain Per Panicle (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1000-1050 ppm; (c) Red Rice variety A2+ ABC Mix 1250-1300 ppm; (d) Red Rice variety A2 + ABC Mix 1500-1550 ppm.



(a) (b) (c) (d)

Figure 11. Weight of Grain Per Panicle (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1000-1050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1250-1300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1500-1550 ppm.

Weight of Empty Grain Per Panicle

Table 4. Weight of Empty Grain Per Panicle Red Rice A2 and Black Rice Black Madrass (grams) ABC Mix Concentration (ppm) Weight of Empty Grain Permalai (grams)

Concentration of ABC Mix (ppm)	Weight of Empty Grain Per Panicle (gram)	
	Red Rice A2	Black Rice Black Madrass
750-800	0,87 bc	0,80 c
1000-1050	0,63 c	0,82 c
1250-1300	1,30 a	0,92 bc
1500-1550	0,93 c	0,72 ab

Note: Numbers followed by the same letter indicate no significant difference in the BNT 5% further test.

Based on Table 4, the best treatment for the observation variable, empty rice grain weight, is the red rice variety A2 with an ABC mix concentration of 1250-1300 ppm, with an average empty rice grain weight of 1.30 grams. The presence of empty grains can be suspected based on the small dominant apex on the panicle, the arrangement of grains on the panicle, and the limited number of

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vascular bundles for transporting assimilates (Aryana et al., 2017). This is because applying silica can extend the panicle and increase grain production (Kumar et al., 2019). Rajab et al. (2023) explain that applying silica can enhance plants' tolerance to environmental stress. Meanwhile, according to Zhang et al. (2018), the application of silica can improve grain quality. The application of silica can also reduce grain damage caused by pests and diseases (Hasanuzzaman et al., 2020).



(a) (b) (c) (d)

Figure 12. Empty Grain Per Panicle (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1000-1050 ppm; (c) Red Rice variety A2+ ABC Mix 1250-1300 ppm; (d) Red Rice variety A2 + ABC Mix 1500-1550 ppm.



(a) (b) (c) (d)

Figure 13. Empty Grain Per Panicle (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1000-1050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1250-1300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1500-1550 ppm.

Weight of Grain per Clump

Table 5 Weight of Grain Per Clump of Red Rice A2 and Black Madrass Rice (grams)

Variety	Concentration of ABC Mix (ppm)			
	750-800	1000-1050	1250-1300	1500-1550
Red Rice A2	56.17 Ba	64.24 Aa	37.72 Cb	39.56 Ca
Black Madrass	23.35 Bb	29.05 Bb	49.98 Aa	34.32 Bb

Note: Numbers filled with the same uppercase letters in the same row and numbers filled with the same lowercase letters in the same column indicate significantly different results based on the DMRT 5% follow-up test.

Table 5 shows that the best treatment interaction on the observation variable of grain weight per hill was in the treatment of red rice variety A2 with an ABC mix concentration of 1000-1050 ppm, with an average of 64.24 grams, and the treatment of black rice variety Black Madrass with a concentration of 1250-1300 ppm, with an average of 49.98 grams. Meanwhile, the interaction of red rice variety A2 ABC mix with a concentration of 1250-1300 ppm showed the lowest treatment with an average of 37.72 grams. This is thought to be because red rice A2 has better genetics for grain production per hill (Yulina et al., 2020). The genes in red rice A2 are more active in regulating grain production (Ezward et al., 2020). Meanwhile, red rice also exhibits greater photosynthetic capacity

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(Haitami et al., 2019). And according to Hasanuzzaman et al. (2020), providing silica can increase the number of grains per hill and panicle length.



(a) (b) (c) (d)

Figure 12. Grain Per Clump (a) Red Rice variety A2+ ABC Mix 750-800 ppm; (b) Red Rice variety A2+ ABC Mix 1000-1050 ppm; (c) Red Rice variety A2+ ABC Mix 1250-1300 ppm; (d) Red Rice variety A2 + ABC Mix 1500-1550 ppm.



(a) (b) (c) (d)

Figure 13. Grain Per Clump (a) Black Rice variety Black Madrass + ABC Mix 750-800 ppm; (b) Black Rice variety Black Madrass + ABC Mix 1000-1050 ppm; (c) Black Rice variety Black Madrass + ABC Mix 1250-1300 ppm; (d) Black Rice variety Black Madrass + ABC Mix 1500-1550 ppm.

Number of Productive Tillers

Table 6. Productive Tillers of A2 Red Rice and Black Madrass Rice (bars)

Varietas	Concentration of ABC Mix (ppm)			
	750-800	1000-1050	1250-1300	1500-1550
Red Rice A2	24.00 Ba	29.67 Aa	21.33 Ba	20.00 Ba
Black madras	20.66 Ba	20.33 Bb	25.00 Aa	22.33 Aa

Description: Numbers filled with the same capital letters in the same row and numbers filled with the same lower-case letters in the same column show results that are not significantly different based on the 5% DMRT follow-up test.

Table 7 Number of Productive Tillers of A2 Red Rice and Black Madrass

Concentration of ABC Mix (ppm)	Weight Productive Tillers (bars)	
	Red Rice A2	Padi Hitam Black Madrass
750-800	24.00 ab	20.67 cd
1000-1050	29.67 a	20.33 d
1250-1300	21.33 cd	25.00 b
1500-1550	20.00 d	22.33 bc

Note: Numbers followed by the same letter indicate no significant difference in the 5% BNT follow-up test.

Based on the research results, the variable number of productive tillers showed a highly significant effect on the interaction between nutrient ratio and variety. A 1% DMRT test (Table 6) showed that the A2 red rice variety had the best results with an ABC mix concentration of 1000-1050 ppm. A 5% LSD test (Table 7) showed that an ABC mix concentration of 1000-1050 ppm produced

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the best results. This is likely because the presence of silica stimulates tiller formation, which is determined by cell division (Rahmayuni et al., 2024). According to research by Zulputra et al. (2014), rice tiller number increases with increased P uptake following silica application, as phosphorus is needed by plants for cell division and for energy in plant metabolism.

DISCUSSION

The growth and productivity of rice plants are influenced by internal and external factors. Internal factors include genetic aspects, hormones, enzymes, and anatomical structure. Genetics is the inherent traits of a plant that determine its yield potential and enable it to optimize the use of sunlight, air, water, and nutrients to efficiently produce biomass (Sihaloho et al., 2024). Meanwhile, external factors include light, temperature, water, nutrients, and soil conditions. Plant nutrition is the set of essential chemical elements required by plants and plays a role, both directly and indirectly, in the plant's metabolic processes and physiological activities (Inaya et al., 2021). The use of appropriate nutrient solutions and growing media can enhance plant productivity (Bahzar, 2017).

Based on the level of plant needs, nutrients are classified into three categories: basic nutrients, macronutrients, and micronutrients. Macronutrients include Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulfur (S). Meanwhile, micronutrients include Iron (Fe), Manganese (Mn), Boron (B), Molybdenum (Mo), Copper (Cu), Zinc (Zn), and Chlorine (Cl) (Inaya et al., 2021). The types of nutrients include macronutrients, micronutrients, vitamins, and hormones. There are five main groups of plant hormones: gibberellins, auxins, cytokinins, and abscisic acid (Maulana et al., 2018).

The benefits of applying silica nutrition include enhancing plant resistance to drought stress through mechanisms that improve tissue water balance, increase photosynthetic activity, and strengthen cell walls. Strengthening cell walls not only makes plants more tolerant of drought stress but also of root disease infections. Another important role of silica is to reduce water loss by decreasing cuticular transpiration while simultaneously increasing CO2 assimilation and stomatal opening (Santi, 2016). Trisnawati et al. (2017) also argue that silica can enhance plant resistance, especially in grasses (Gramineae), against diseases and pests by specifically affecting epidermal cells, thickening cell walls, and reducing transpiration, thereby decreasing pest attacks and disease infections. Research shows that the growth of rice, cucumbers, and tobacco is significantly disturbed when silica is not added, and that visual symptoms of silica deficiency also occur. Silica can improve plant growth by increasing resistance to lodging, drought, diseases, and pests, and by strengthening the leaves.

Based on the research results, plant height shows a significant effect on the variety treatment. According to the follow-up BNT 5% test in Table 2, the red rice variety treatment A2 has the highest yield. According to Afdila et al. (2021), plant height is strongly influenced by a plant's genotype. Based on the research data, the factor that affects plant height is variety. This is suspected to be due to genetic traits that have different characteristics. As a result of the genotype, plant height also differs.

According to the research by Yulina et al. (2020), the high plant diversity during the generative phase indicates that plant characteristics are predominantly influenced by genetic factors. The height of plant stems is influenced by traits that determine the variety's yield potential. Additionally, variation in plant height among varieties arises because each genotype has distinct genetic factors and characteristics. Differences in these genotype characteristics lead to variations in the regulatory

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genes. Differences in genetic composition are among the factors that cause diverse plant appearances, in this case, plant height (Oktavianty, 2023).

Based on the research results, the root length variable was not significant. This is suspected to be due to the difference in silica (Si) content not being as great. According to Sahebi et al. (2015), silica accumulation in the roots can strengthen the cell walls and increase resistance to salinity. This root growth can also trigger greater translocation of assimilates to the roots, reducing nutrient allocation to other organs and thereby affecting biomass production and plant productivity (Gian et al., 2021).

Based on the research results, the panicle length variable showed no significant effect. This is suspected because the root length variable also showed insignificant results. This is suspected to be due to differences in silica (Si) content, or to Si content not being significantly different. According to Rahyumi et al. (2024), silica can increase the length of rice panicles, and with the increase in the application of silica, rice leaves become more upright. Similarly, according to Malav et al. (2016), rice panicle length increases with silica application.

Based on the research results, the variable weight of 1000 grains showed a highly significant effect on the nutritional ratio treatment. Based on the 1% DMRT follow-up test in Table 3, the ABC mix treatment at 1500-1550 ppm had the best results. This is suspected to be because the seed weight is influenced by photosynthesis that occurs after flowering (Tampoma et al., 2017). Meanwhile, Yuniarti et al. (2017) explain that silica does not affect the weight of the grain because the working mechanism of silica requires time to dissolve.

Based on the results of the conducted research, the variable weight of the filled rice grains shows a significant effect on the interaction between the nutritional ratio treatment and the variety treatment. According to the 5% DMRT follow-up test in Table 4, the red rice variety A2 and the ABC mix treatment at 1500-1550 ppm have the highest yield. The number of filled rice grains from the plants used was not affected by the variety treatment and the interaction between those treatments (Abbas et al., 2018). This is suspected to be because the red rice variety A2 has better genetic traits than the black rice variety Madras for rice grain production (Yulina et al., 2020). Meanwhile, according to Ezward et al. (2020), red rice has more effective genes in regulating grain production. The application of silica can extend panicle length and increase grain yield (Kumar et al., 2019). The difference in the percentage of filled grains is suspected to be due to genetic factors in each rice variety. The high percentage of filled grains per panicle is strongly influenced by the number of grains per panicle and nutrient availability. Suitable growing conditions tend to stimulate the initiation of perfect panicles, thereby increasing the chances of grain formation. However, as the number of grains formed increases, the burden on the plant to develop filled grains increases. If, during grain filling, nutrient availability is insufficient, many unfilled grains will form. The percentage of filled grains is one of the indicators of crop productivity; the higher the percentage of filled grains obtained by a variety, the higher the productivity of that variety (Mahmud et al., 2014).

Based on the research results, the variable weight of empty rice grains had a significantly different effect on the nutrient ratio treatment. According to the further DMRT 5% test in Table 5, the ABC mix treatment at 1250-1300 ppm had the best results. The empty grains can be presumed due to the presence of small apex dominance on the panicle, the arrangement of grains on the panicle, and the limited vascular bundles for the transport of assimilates (Aryana et al., 2017). This is because applying silica can extend the panicle and increase grain production (Kumar et al., 2019). Rajab et al. (2023) explain that the application of silica can enhance a plant's tolerance to environmental stress. Meanwhile, according to Zhang et al. (2018), the application of silica can improve the quality

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of rice grains. The provision of silica can also reduce the damage to grains caused by pests and diseases (Hasanuzzaman et al., 2020).

Based on the results of the conducted research, the variable of grain weight per clump shows a significantly different effect on the interaction between the nutrient ratio treatment and variety treatment. Based on the 5% DMRT post hoc test in Table 6, the treatment of red rice variety A2 and ABC mix at 1000-1050 ppm yields the best results. This is suspected because red rice A2 has better genetics for clump grain production (Yulina et al., 2020). The genes present in red rice A2 have more active genes in regulating grain production (Ezward et al., 2020). Meanwhile, red rice also has better photosynthesis capability (Haitami et al., 2019). Additionally, according to Hasanuzzaman et al. (2020), applying silica can increase the number of grains per clump and the length of the panicle.

Based on the results of the conducted research, the number of productive tillers shows a very significant effect on the interaction between nutritional ratio treatments and varieties. Based on the 1% DMRT further test in Table 7, the treatment of red rice variety A2 with an ABC mix concentration of 1000-1050 ppm yields the best results. Meanwhile, in the 5% BNT further test documented in Table 8, it indicates that the ABC mix concentration of 1000-1050 ppm also produces the best results. This is suspected to be due to the presence of silica, which can stimulate tiller formation by influencing cell division (Rahmayuni et al., 2024). According to the research by Zulputra et al. (2014), the number of rice tillers increased with greater P absorption due to the application of silica, as phosphorus is a nutrient required by plants for cell division and serves as energy in plant metabolic processes.

CONCLUSION

Based on the observations that have been made, it is concluded that there is an interaction between the concentration of ABC mix (1000-1050 ppm) and the red rice variety A2 on the number of productive tillers (29.67 stems). The application of ABC Mix at 1500-1550 ppm has a significantly different effect on the weight of 1000 grains (27.55 grams). The red rice variety A2 shows better growth performance compared to black rice in terms of plant height (86.64 cm).

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CONFLICT OF INTEREST

Based on the results of the conducted research, to minimize nutrient loss from ABC Mix due to evaporation, it is advisable to conduct research in a greenhouse to optimize the application of ABC Mix nutrients in a soilless culture system.

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