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Application of Jarwo Planting System and Fertiphos Fertilizer on The Growth and Yield of Black Rice Mutant M4

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ABSTRACT

This study aims to examine the interaction between the dose of Fertiphos fertilizer and the JARWO (JARWO) planting pattern on the growth and yield of black rice mutant rice. The experiment was conducted in Jorong Labuah, Agam Regency, and the Seed Science and Technology Laboratory, Andalas University, Padang, from February to June 2024. A Completely Randomized Design (CRD) with two factors was used, namely the JARWO planting system (2:1, 3:1, 4:1) and the dose of Fertiphos fertilizer (0 kg/ha, 100 kg/ha, 200 kg/ha, 300 kg/ha). Data were analyzed using the F test at the 5% level, followed by Duncan's New Multiple Range Test (DNMRT) if significant. The results showed a significant interaction between the dose of Fertiphos fertilizer and the JARWO planting pattern on the growth and yield of black rice mutant rice. Fertiphos fertilizer dose of 200 kg/ha gave the best results on the total number of grains per panicle, the number of filled grains per panicle, the total weight of grains per panicle, and the weight of filled grains per clump. The JARWO 2:1 planting pattern gave the best results on the total number of tillers, the total number of grains per panicle, the number of filled grains per panicle, and the total weight of grains per panicle.

Keywords: Fertiphos, Growth, Jarwo, M4 Black Rice, Mutant Rice, Yeald

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an essential commodity for humans because more than half of the world's population depends on it as their main food source (Laskari et al., 2022). Rice has become a primary need for the Indonesian population, because of its function as a source of energy and carbohydrates. Rice is divided into white rice and colored rice, including red rice and black rice. Colored rice not only functions as a staple food but also functions as a functional ingredient. (Indrasari et al., 2010).

Ishak (2023) has succeeded in converting white rice of the Sidenuk variety into black rice through mutation breeding. This research is mainly aimed at increasing the variability of black rice, which is currently not much compared to other colored rice, such as red rice and brown rice. The results of further research have obtained black rice lines with a more stable black color character and are passed on to the next generation (genetics). However, to see the yield of the mutant rice, further research is still needed, especially research related to the rice cultivation system, such as fertilization, plant population, and planting patterns.

Fertilizer is a production facility that plays an important role in increasing the productivity of food crops. In agricultural cultivation, fertilizer is one component of the technology package that cannot be left out in efforts to increase crop production. Increasing crop production through intensification of agricultural cultivation systems requires fertilizer in adequate quantities (Suryono, 2003). Although the use of fertilizer is closely related to increasing the harvest and growth of rice plants, what is no less important is the correct method of applying fertilizer and paying attention to the balance of nutrients it contains. According to Nyanjang (2003), complete and balanced fertilization greatly affects the growth and yield of rice plants because it can add and restore nutrients that have been lost, either washed out or carried by plants during harvest.

Continuous use of chemical fertilizers at high doses can harm the environment and can reduce the level of efficiency of their use. In this regard, it is necessary to increase fertilization efficiency by managing fertilizers appropriately according to plant needs and land conditions so that plant productivity remains high. Excessive fertilizer application is not necessarily good, considering that the fertilizer content that is lost in vain due to evaporation or dissolving in water without being utilized by plants will actually be wasteful or even damage soil fertility.

Fertilization is one of the determining factors in efforts to increase food productivity (Kasniari and Supadma, 2007). Until now, there has been a tendency for farmers to use inorganic fertilizers in plant cultivation efforts for practical reasons. The results of Kaya's (2014) study showed that in intensive rice fields, most rice plants were no longer responsive to inorganic P and K fertilization, because the application of inorganic fertilizers can damage the environment. To reduce the large differences, additional organic and biological fertilizers are needed.

One of the fertilizers that is currently available and has begun to be widely used by rice farmers is Fertiphos fertilizer. Fertiphos fertilizer is a phosphate fertilizer that comes from natural materials such as guano, straw residues, animal manure, clay and is equipped with macro and micro elements. This fertilizer is a new innovation that helps farmers to fulfill the nutrient needs of plants. Fertiphos fertilizer contains Phosphate (P): 20%, Magnesium (Mg): 3%, Sulfur (S): 1%, Boron (Br): 0.2%, and Calcium (Ca): 20%, (Suryono, 2018). However, there has not been much research on the use of Fertiphos for rice plants, including the right dosage to increase rice growth and yield. Based on the recommendations on the label, Fertiphos fertilizer is given at a dose of 200 kg/ha for rice planting with a commonly used cultivation system. Suryono's (2003) research on the IR64 rice variety in alluvial rice fields showed that the application of Fertiphos fertilizer at a dose of 225 kg/ha was able to increase yields by 5.57% compared to the control plot without Fertiphos fertilization. The use of Fertiphos fertilizer in the Jarwo cultivation system has never been done. Another factor that also affects rice production is the planting system. The planting system can affect the growth and yield of rice plants (Lita et al., 2013). One of the rice planting systems that is currently widely used because it can increase rice productivity is jajar legowo, abbreviated as JARWO. In principle, the JARWO planting system is to increase the population by regulating the planting distance. This planting system also manipulates the layout of the plants, so that the clumps of plants are partly.

2. MATERIAL AND METHODS

The research in the form of an experiment was carried out from February to June 2024 which took place in Jorong Labuah, Nagari Sungai Batang, Tanjung Raya District, Agam Regency with an altitude of ± 637 m above sea level at the geographical coordinates -0 ° 20 "7'S 100 ° 14'1" E and Seed Technology Science, Faculty of Agriculture, Andalas University, Padang.

The materials used in this study were Sidenuk variety rice seeds from M4 plant selection (black rice mutant line), urea fertilizer, Phonska, Fertiphos, and pesticides for plant care from pests and diseases, cow manure.

The equipment used in this study were hoes and tractors for land processing, netting, pest and plant disease sprayers, weed removers, label paper, 5 kg clear plastic, sacks, 0.5 mm sieve, digital scales, ovens, label paper, plastic folders, sickles, meters, observation aids (small notes, pens, pencil, ruler, marker, camera.

The research was conducted using an experimental method arranged using a factorial Completely Randomized Design (CRD). The first factor consisted of 3 levels and the second factor consisted of 4 levels, so 12 combination treatments were obtained. Each experimental unit consisted of a plot measuring 125 cm x 225 cm. Each experimental unit was repeated 3 times. The implementation of the research is presented in the following flow diagram:

Land preparation was carried out by plowing using a tractor twice. The first plowing was done by turning the soil and flooding it, followed by the second plowing a week later to muddy the soil. After mudding, the soil was leveled and divided into 36 plots measuring 125 cm x 225 cm.

Soil sampling was carried out at five points in the rice fields with a depth of 0-20 cm. From each point, five sub-samples were taken which were then composited into one soil sample. The soil samples were air-dried for one week, then finely ground and sieved with a 0.5 mm sieve. Soil chemical analysis was carried out at the Soil and Environmental Laboratory of PT. Widiadi Bintang Sains to determine properties such as N-Total, P-Total, K-Total, C-Organic, and soil pH, which were then used to assess soil fertility status.

The rice seeds used came from M4 mutant plants that were previously stored in a refrigerator. The seeds were soaked for 1 hour to select the full seeds, then soaked again for 2 x 24 hours for imbibition. After soaking, the seeds were air-dried and sown in a planting box containing a mixture of 50% soil and 50% cow manure. The seeds were sown evenly in the box and covered with a sack for two days before being opened.

The experimental plot label was attached to each plot using a 20 cm x 15 cm plastic folder written with a permanent marker, attached to a 100 cm high bamboo to avoid treatment errors and facilitate observation.

Planting was carried out after the seedlings were 14 days old after sowing (HSS), with one seedling per planting hole according to the JARWO planting distance (JARWO) of 2:1, 3:1, and 4:1, to evaluate the potential for plant growth and yield.

The maintenance carried out included irrigation, replanting, weeding, fertilization, treatment, harvesting and pest and disease control. Observations made included plant height, grain weight per clump, yield per hectare. The implementation of the research is presented in the following flow diagram:

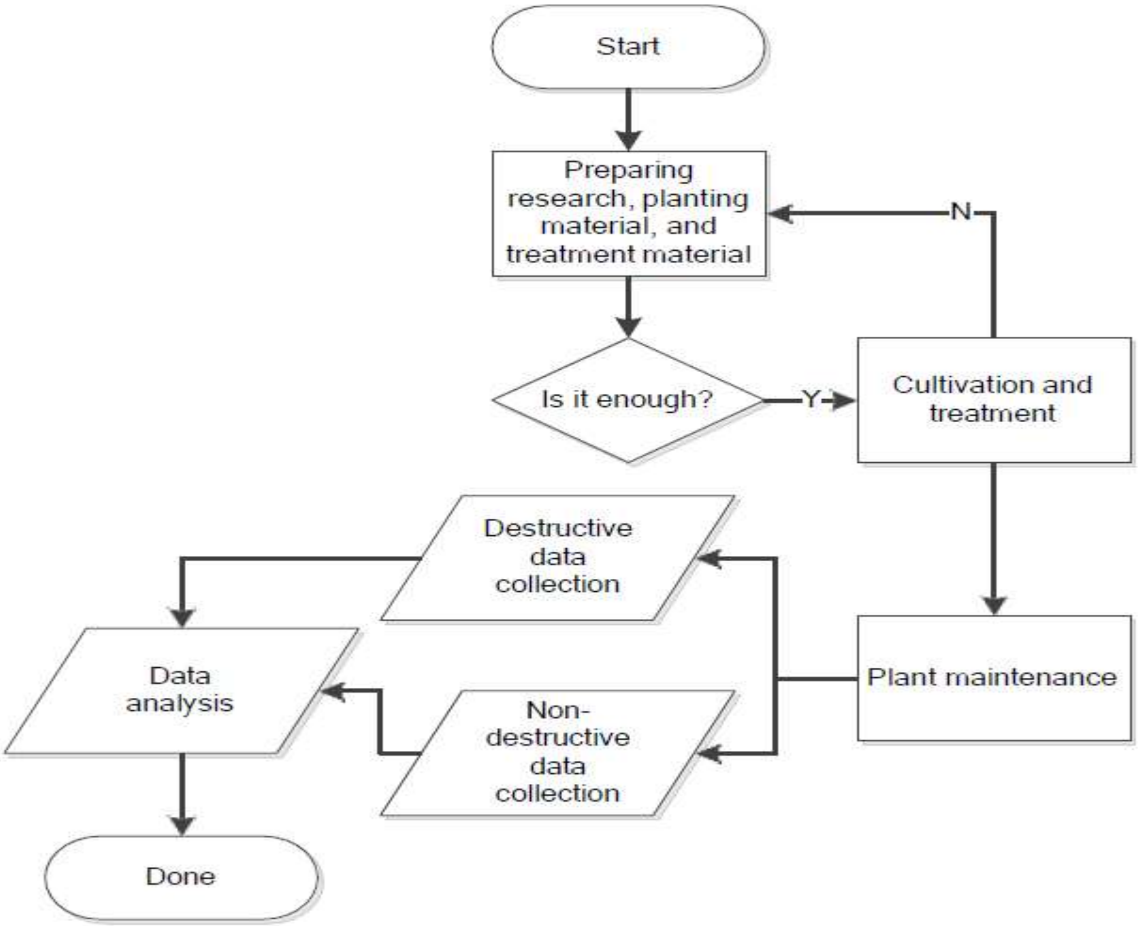

Figure 1. Research flow diagram

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

The results of the analysis of variance showed that the height of the M4 black rice mutant rice plant was not affected by the interaction between the JARWO planting system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on plant height. The average data on the height of the black rice mutant rice plant can be seen in Table 1.

Table 1 shows that increasing the dose of Fertiphos fertilizer showed no significant difference in plant height. Likewise, variations in the JARWO rice planting system also showed no significant difference in plant height. In general, the height of rice plants ranged from 107.73 cm to 124.40 cm with an average plant height of 113.42 cm. Based on the Rice Standard Evaluation System, the characteristics of the height of the rice plant are included in the medium category (Suhardjadinata, 2022). Fertilizer administration according to the dose and general plant needs will be able to increase plant growth and yield. To a certain extent, each increase in the dose of fertilizer can increase plant height. However, in this experiment, increasing the dose of Fertiphos did not increase the height of the M4 black rice mutant rice plant. According to the Soil Research Center (2024), increasing the dose of fertilizer does not always increase plant growth and yield or at some point there will be an increase in the dose that does not increase plant growth and yield. It is further stated that fertilization is greatly influenced by soil nutrient status, soil acidity, physical and biological properties of the soil, as well as plant types and varieties and the effect of fertilization on the soil is very specific and different in each location.

Table 1. Plant height of the M4 black rice mutant treated with Fertiphos fertilizer doses and the JARWO planting system

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	..cm..				
2 : 1	121,60±2,66	107,87±3,63	109,67±3,38	107,73±4,13	111,71
3 : 1	111,33±4,12	114,13±4,40	124,40±2,82	110,27±2,61	115,03
4 : 1	122,60±2,55	107,93±3,63	110,27±3,50	114,73±2,64	113,54
Average	118,51	109,97	114,78	110,91	113,42
CV = 8,49 %					

Notes: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

The increase in the dose of Fertiphos fertilizer that did not provide a significant difference between doses was thought to be due to the nutritional needs of rice plants being met by the nutrients available in the soil and added by the addition of basic fertilizers. From the results of soil analysis, it can be seen that although the total N content was low, the total P and total K were moderate (Table 1), but added with basic fertilizers of 100 kg/ha Urea and 200 kg/ha Phonska, so it is thought that the addition of these fertilizers has met the nutritional needs of the black rice mutant. This is what caused the increase in the dose of Fertiphos not to increase the height of the black rice mutant rice plants. In addition, the character of plant height is also influenced by the genetic constitution of each type/genotype of plant. Certain plant genotypes have a maximum capacity for plant height characters, so that any environmental modification, such as the addition of fertilizers, will not be able to increase plant height again. Nazirah and Damanik (2015) stated that plant height is determined by the genetic factors of a genotype. Furthermore, Mildaerizanti (2008) also stated that differences in plant height are more determined by genetic factors. The differences in the JARWO planting system also did not have a significant effect on plant height. This is thought to be because the three JARWO planting systems are able to provide ideal conditions for the growth of black rice mutant rice plants. This is in line with research conducted by BPTP West Sumatra (2014) which showed that the JARWO planting system had no significant effect on plant height, but had a significant effect on the total number of tillers and the number of productive tillers.

3.2 Total Tiller Number

The results of the analysis of variance showed that the total tiller number of M4 black rice mutant rice was significantly affected by the interaction between the JARWO planting pattern system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment, had a significant effect on the total tiller number of M4 black rice mutant rice. Data from the DNMRT analysis at the 5% level of the total tiller number of M4 black rice mutant rice affected by the Fertiphos fertilizer dose and the JARWO planting system can be seen in Table 2.

Table 2. Total number of tillers of the M4 black rice mutant treated by the dose of Fertiphos fertilizer and the JARWO planting system.

JARWO	Fertiphos Fertilizer Dosage			
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha
	-- stem--			
2 : 1	18,60±1,06 Bb	20,20±0,57 ABa	23,40±1,90 Aa	21,47±1,43 ABa
3 : 1	23,87±0,78 Aa	19,33±1,07 BCa	19,00±0,82 Cb	22,53±0,78 ABa
4 : 1	19,07±0,83 Ab	17,87±0,82 Aa	19,07±0,84 Ab	20,53±1,31 Aa
CV = 9,77 %				

Note: Numbers in the same column followed by a lowercase letter, and numbers in the same row followed by the same capital letter are not significantly different according to the DNMRT test at the 5% level.

Table 2 shows that the total number of tillers of M4 mutant rice in the Ferthipos 0 kg/ha treatment shows that the total number of tillers in the JARWO 2:1 system is significantly different from the JARWO 3:1 system and the JARWO 4:1 system. However, there is no significant difference between the JARWO 3:1 and 4:1 systems. In the Fertiphos 100 kg/ha and 300 kg/ha treatments, there is no significant difference between the JARWO 2:1, 3:1, and 4:1 systems. In the Fertiphos 200 kg/ha treatment, there is no difference in the total number of tillers in the JARWO 2:1 and 4:1 planting systems. However, both are significantly different when compared to the JARWO 3:1 planting system. In the JARWO 2:1 planting system, in general, increasing the Fertiphos dose will increase the total number of tillers of mutant rice and there is no significant difference between the doses of 100 kg/ha, 200 kg/ha, and 300 kg/ha. Likewise, there was no significant difference between the Fertiphos doses of 0 kg/ha, 100 kg/ha, and 300 kg/ha. On the other hand, in the JARWO 3:1 planting system, increasing the Fertiphos fertilizer dose to 200 kg/ha actually reduced the total number of mutant rice tillers. However, the Fertiphos dose of 0 kg/ha was not significantly different from the dose of 300 kg/ha. In the JARWO 4:1 planting system, there was no significant difference between each dose of Fertiphos fertilizer treatment. The difference in the JARWO planting system had a significant effect on the total number of tillers. According to Sulistiani (2009), a fairly loose rice planting distance will provide flexibility for the growth of rice tillers, maximum sunlight is received by all leaves for photosynthesis and grain production. The number of productive tillers is one of the agronomic components that affects the rice harvest (productivity). Syarief (2005) said that sufficient availability of nutrients will be able to increase plant height, stimulate root system growth, increase production yields, and increase leaf growth so that it can increase the photosynthesis process.

In general, it can be said that increasing the dose of fertilizer can increase the total number of tillers. The higher the dose of Fertiphos fertilizer to a certain extent can affect the total number of tillers. This is in accordance with the opinion of Agustina (1990), that the relationship between fertilizer dose and plant yield follows a quadratic pattern, namely that giving fertilizer up to a certain dose can increase plant yields, but if the fertilizer is given at an inappropriate dose (excessive) it can reduce yields.

According to (Sari et al., 2023) the administration of organic and inorganic fertilizers in combination at a certain dose (50% organic fertilizer + 50% inorganic fertilizer) produces the highest number of rice tillers (28 tillers per clump). A higher dose of inorganic fertilizer (100% inorganic fertilizer) actually produces a lower number of tillers (23 tillers per clump). The ability of plants to produce tillers is influenced by the availability of nutrients and plant genetic factors (Mugiono, 2009). The formation of the number of tillers in rice plants is influenced and very sensitive to fertilization. Providing sufficient fertilizer will increase the number of tillers produced. Rice plants will produce a number of productive tillers if the dose given is appropriate. Conversely, if given with an inappropriate dose (low or excessive), then its growth will be inhibited. This is inseparable from the role of the P element which is able to stimulate the growth of the number of productive tillers, so that by giving the right dose it will increase the number of tillers produced (Fajri & Syukrı, 2016).

3.3 Flowering Age

The results of the analysis of variance showed that the flowering age of the M4 black rice mutant rice plant was not affected by the interaction between the JARWO planting system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on the flowering age of the M4 black rice mutant rice plant. The average flowering age data of the black rice mutant rice that was not affected by the administration of Fertiphos fertilizer and the JARWO planting system can be seen in Table 3.

Table 3. Flowering age of M4 black rice mutant treated with Fertiphos fertilizer dose and JARWO planting system

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	..day..				
2 : 1	60,53±0,59	60,53±0,54	60,27±0,52	60,93±0,46	60,57
3 : 1	60,60±0,51	60,33±0,54	60,73±0,50	60,93±0,43	60,65
4 : 1	60,27±0,47	60,40±0,60	60,53±0,51	61,53±0,33	60,38
Average	60,46	60,42	60,51	61,13	60,53
CV = 1,19 %					

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

Table 3 shows that increasing the dose of Fertiphos fertilizer showed no significant difference in the flowering age of black rice mutant rice. Likewise, the variation of the JARWO rice planting system also showed no significant difference in the flowering age. In general, the flowering age of black rice mutant rice plants ranged from 60.27 days to 61.53 days with an average flowering age of 60.53 days. Based on the IBPRG (1980) Rice Standard Evaluation System, the characteristics of the flowering age of these rice plants are included in the early maturing category (Suhardjadinata, 2022). The flowering age of plants is mainly influenced by genetic factors. The flowering age of plants is an important phase in their life cycle, marking the transition from vegetative to reproductive growth. Genetic factors play a very dominant role in determining when exactly a plant will flower (Smith & Jones, 2018). The average flowering age in the JARWO planting pattern treatment has a value between 60.38-60.65 days. This shows that the flowering age of the M4 black rice mutant rice plant and the dose of Fertiphos fertilizer with the JARWO planting system are more influenced by the genetics of the black rice plant.

Faster flowering age is a highly desired criterion because it is one of the characteristics of early maturing rice. Optimal rice plant growth can be characterized by faster flowering age (Marlina et al., 2017). Differences in flowering age occur due to differences in the duration of genotypes in the vegetative growth phase and differences in plant response to environmental conditions according to their genetic capabilities. Rice plants require nutrients, both macronutrients and micronutrients to support the process of photosynthesis. Differences in flowering age indicate different plant responses to different environmental conditions (Cahya and Ninuk 2018). The longer the vegetative growth phase, the longer the flowering age will be.

3.4 Harvest Age

The results of the analysis of variance showed that the harvest age variable of the M4 black rice mutant rice was not affected by the JARWO planting pattern system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on the harvest age variable of the M4 black rice mutant rice. The average harvest age data of the M4 black rice mutant rice that was not affected by the Fertiphos fertilizer dose and the JARWO planting system can be seen in Table 4.

Table 4. Harvest age of M4 black rice mutant treated with Fertiphos fertilizer dose and JARWO planting system

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	..day..				
2 : 1	103,06±0,27	102,93±0,26	103,13±0,26	103,13±0,26	103,31
3 : 1	103,20±0,28	102,80±0,27	103,20±0,24	103,53±0,24	103,18
4 : 1	103,00±0,16	103,46±0,27	103,40±0,23	103,47±0,21	103,33
Average	103,08	103,06	103,24	103,37	103,27
CV = 0,35 %					

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

Table 4 shows that the harvest age of the black rice mutant rice plants ranges from 102.80 days to 103.53 days with an average harvest age of 103.27 days. Based on the Center for Rice Research (2015), the grouping of the characteristics of the harvest age of rice plants into 6 categories, namely ultra early maturing (<85 days), super early maturing (85-94 days), very early maturing (95-104 days), early maturing (105-124 days), medium (125-150 days) and deep (>150 days). The flowering age of the rice plants is included in the early maturing category.

The effect of planting distance on the intensity of proper sunlight exposure can help plants grow faster. Plants that have the right planting distance will increase plant development, the plant canopy does not cover the plants so that plant growth is better. The difference in harvest age is influenced by the generative phase or flowering phase of the plant. The grain located at the tip and base of the panicle has a different length of grain filling period and cooking time. Harvest age is one of the characteristics that is taken into account in agriculture, especially in rice plants (BB Padi, 2019).

3.5 Number of Productive Tillers

The results of the analysis of variance showed that the variable number of productive tillers of the M4 black rice mutant rice was not affected by the JARWO planting pattern system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on the number of productive tillers of the M4 black rice mutant rice. The average data on the number of productive tillers of the M4 black rice mutant rice that were not affected by the Fertiphos fertilizer dose and the JARWO planting system can be seen in Table 5.

Table 5. Number of productive tillers of the M4 black rice mutant treated with Fertiphos fertilizer doses and the JARWO planting system.

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	.. stem..				
2 : 1	14,93±0,66	17,20±0,38	15,27±1,07	15,60±0,96	15,75
3 : 1	15,40±0,67	15,13±0,53	13,87±0,68	14,13±0,57	14,63
4 : 1	14,53±0,73	14,47±0,77	13,20±0,97	15,00±0,68	14,30
Average	14,95	15,60	14,11	14,91	14,56
CV = 11,57 %					

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

Table 5 shows that the increase in the dose of Fertiphos fertilizer showed no significant difference in the number of productive tillers of black rice mutant rice. Likewise, the variation of the JARWO rice planting system also showed no significant difference in the number of productive tillers. In general, the number of productive tillers of black rice mutant rice plants ranged from 14.30-15.75 stems. According to (Perwira et al., 2022) tillers in rice plants are divided into five groups (<5) very few categories, (5-9) few categories, (10-19) moderate categories, (20-25) many categories and (>25) very many categories. Based on these categories, the number of productive tillers in the M4 mutant of black rice is included in the moderate tiller type.

Well-growing rice seedlings will affect more optimal rice production results. Rice seedlings will grow into productive seedlings forming panicles after entering the generative period which will produce rice grains. Adequate nutrition will support the acceleration of fertilization and grain filling, producing fuller and heavier grains. The availability of sufficient nutrition in the generative phase of rice plants is very important to improve the quality and quantity of the harvest (Azalika et al., 2018). In the 2:1 planting pattern system, rice has a value of 15.75 stems, less than the 3:1 or 4:1 planting patterns. This is because the 2:1 planting pattern provides more space for each plant to grow, so that they can absorb nutrients and water more optimally. This can increase overall plant productivity compared to denser systems such as 3:1 or 4:1. Thus, the number of productive rice seedlings tends to be greater in the JARWO 2:1 planting system. This is in line with Ridwan's opinion, who has conducted research (2000) that the number of productive plant shoots is influenced by the total number of shoots per clump, the greater the number of shoots, the greater the number of productive shoots.

The difference in the JARWO planting system has a significant effect on the number of productive tillers. This is because the three JARWO planting systems can provide ideal conditions for the growth of the number of productive tillers of black rice mutant rice. This is in line with research conducted by BPTP West Sumatra (2014) which shows that the JARWO planting system has a significant effect on the total number of tillers and the number of productive tillers.

The number of tillers in rice plants can be influenced by the flooding process during the vegetative phase which plays a very important role in the formation of the number of tillers, the short age of seed transfer, the planting season, planting one stem and the fertility of the soil causing the plant to increase the number of tillers. According to Husana (2010) the number of tillers will be maximized if the plant has good genetic characteristics coupled with environmental conditions that are in accordance with plant growth and development.

The low number of productive tillers compared to the total number of tillers is due to competition between tillers for nutrients. Unproductive tillers will eventually die on their own because the nutrient supply will move to productive tillers compared to unproductive ones. Competition between tillers in absorbing nutrients causes less vigorous tillers to tend to lose the competition and die, while more dominant tillers will get more nutrients and grow better" (Smith, 2015)

The formation of the number of tillers in rice plants is influenced and very sensitive to fertilization. Providing sufficient fertilizer will increase the number of productive tillers produced. Rice plants will produce a number of productive tillers if the dose given is appropriate. Conversely, if given with an inappropriate dose (low or excessive), then its growth will be inhibited. This is inseparable from the role of the P element which can stimulate the growth of the number of productive tillers, so that by providing the right dose it will increase the number of tillers produced (Fajri & Syukrı, 2016).

3.6 Total Grain Weight Per Clump of Rice

The results of the analysis of variance showed that the total grain per clump of the M4 black rice mutant rice was significantly affected by the JARWO planting pattern system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment, had a significant effect on the total grain per clump of the M4 black rice mutant rice. Data from the DNMRT analysis results at the 5% level of the total grain weight per clump of the M4 black rice mutant rice affected by the Fertiphos fertilizer dose and the JARWO planting system can be seen in Table 6.

Table 6. Total grain weight per clump of M4 black rice mutant treated with Fertiphos fertilizer dose and JARWO planting system.

JARWO	Fertiphos Fertilizer Dosage			
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha
	..gram..			
2 : 1	35,74±1,92 AA	40,51±2,98 Aa	41,42±2,39 AB	44,67±4,29 Aa
3 : 1	36,17±2,30 BA	42,84±3,47 Ba	60,21±4,22 AA	38,59±1,66 Ba
4 : 1	38,21±4,63 ABa	34,11±2,74 ABa	43,86±1,97 Ab	26,53±0,77 Bb
CV = 16,68 %				

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

Table 6 shows that there is an interaction between JARWO and the Fertiphos fertilizer dose. In the JARWO 3:1 planting pattern, the highest weight of filled grain per panicle of M4 mutant rice black rice was obtained at a Fertiphos fertilizer dose of 200 kg/ha, which was 60.21 g/panicle. There was no significant difference in the weight of filled grain per panicle of M4 mutant rice black rice between Fertiphos fertilizer doses of 0 kg/ha, 100 kg/ha, and 300 kg/ha. In the JARWO 2:1 planting pattern, the highest weight of filled grain per panicle of M4 mutant rice black rice was obtained at a Fertiphos fertilizer dose of 300 kg/ha, which was 44.67 g/panicle. There was no significant difference in the weight of filled grain per panicle of M4 black rice mutant rice between Fertiphos fertilizer doses of 0 kg/ha, 100 kg/ha and was not significantly different from the Fertiphos fertilizer dose of 200 kg/ha. In the JARWO 4:1 planting pattern, the highest weight of filled grain per panicle of M4 black rice mutant rice was obtained at a Fertiphos fertilizer dose of 200 kg/ha, which was 43.86 g/panicle. There was no significant difference in the weight of filled grain per panicle of M4 black rice mutant rice between Fertiphos fertilizer doses of 300 kg/ha, but was significantly different from Fertiphos fertilizer doses of 0 kg/ha and 100 kg/ha.

Variables of the average total grain weight per clump of M4 black rice mutant rice and Fertiphos Fertilizer Dosage with the JARWO planting system have values between 26.53-60.21 g. IBPGR IRRI (1980) provides standards for the character of total grain weight per clump categorized into 3 groups, namely light weight (<25 g), medium (25-50 g) and heavy (> 50 g). Table 13 total grain weight per clump of all mutants including the medium and heavy weight categories in JARWO 3:1 at a dose of Fertiphos fertilizer at a treatment of 200 kg/ha. This is due to the type of mutant factor planted also affecting the total grain weight per clump. Grain filling in plants depends on the results of plant photosynthesis, because the higher the photosynthesis of plants means the higher the plants produce starch that can fill the grain well. Starch is the main component in rice grains, and plays an important role in determining the quality of grain. According to (Lestari et al., 2022) the provision of organic fertilizer and NPK can increase the starch content in rice grains. According to (Suhartono et al., 2016) the starch content in rice is influenced by genetic and environmental factors. Another possibility that the grain is not filled is the distribution of photosynthate to the panicle is one of the factors that can be taken into account in filling the grain. In the study (Yang et al., 2002) the possibility of poor translocation and partition of assimilation from leaves as a source and stems at an important stage of grain filling failed to maintain the development of a large number of grains.

The weight of grain per hill is related to the percentage between the weight of empty grain and the weight of full grain, panicle length, total tillers and productive tillers. The small number of productive tillers affects the decrease in grain weight per hill (Hatta, 2011). The length of the panicle also affects the number of grains per hill because the longer a panicle, the higher the number of grains in one panicle. According to Natawijaya (2012), the higher the number of grain-rich grains, the higher the weight of grain per clump.

3.7 Yield Per Ha

The results of the analysis of variance showed that the yield per hectare of the M4 black rice mutant rice was not affected by the JARWO planting pattern system and the Fertiphos fertilizer dose. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on the yield per hectare of the M4 black rice mutant rice. The average data on the yield per hectare of the M4 black rice mutant rice that was not affected by the Fertiphos fertilizer dose and the JARWO planting system can be seen in Table 7.

Table 7 shows that the increase in the dose of Fertiphos fertilizer showed no significant difference in the yield per hectare. Likewise, the variation of the JARWO rice planting system also showed no significant difference in the yield per hectare. In general, the yield per hectare of rice ranged from 5.33 tons/ha to 6.88 tons/ha with an average yield per hectare of 6.11 tons/ha. This is because the amount of rice yield per hectare is determined by its production components. The yield components include the number of panicles per clump, the number of seeds per panicle, the weight of 1000 seeds and the percentage of filled grain. All of these yield components show almost the same results, so that the productivity of the rice produced is also the same. In addition, the large population in the JARWO 3:1 pattern provides a fairly open space with empty aisles so that sunlight can be utilized by rice plants evenly for the photosynthesis process. According to Pangerang (2013) the JARWO planting system can also increase yields due to the effect of edge plants which are expected to provide high production and better grain quality, increase the number of plant populations/clumps per hectare, there is empty space for water management, increase plants receiving optimal sunlight which is useful in the process of photosynthesis. The yield of plants per hectare is influenced by the number of tillers formed and the number of productive tillers. As in this experiment, the more tillers that are able to produce panicles, the more full grain is produced, so that the yield of plants per plot and per hectare will be higher.

Table 7. Yield per hectare of M4 black rice mutant treated with Fertiphos fertilizer dose and JARWO planting system.

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	..ton/ha..				
2 : 1	6,15±0,40	6,28±0,21	5,83±0,59	5,83±0,14	6,02
3 : 1	5,33±0,28	5,99±0,21	6,88±0,24	5,92±0,37	6,03
4 : 1	6,36±0,36	5,85±0,52	6,60±0,37	6,34±0,61	6,29
Average	5,94	6,04	6,44	6,03	6,11
CV = 11,08 %					

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

3.8 Weight of 1000 Grains

The results of the analysis of variance showed that the weight of 1000 grains of the M4 black rice mutant rice was not affected by the JARWO planting pattern system and the dose of Fertiphos fertilizer. Likewise, each single treatment, both the JARWO planting pattern system treatment and the Fertiphos fertilizer dose treatment did not have a significant effect on the weight of 1000 grains of the M4 black rice mutant rice. The average weight data of 1000 grains of the M4 black rice mutant rice that were not affected by the dose of Fertiphos fertilizer and the JARWO planting system can be seen in Table 8.

Table 8. Weight of 1000 grains of M4 black rice mutant treated with Fertiphos fertilizer dose and JARWO planting system

JARWO	Fertiphos Fertilizer Dosage				Average
	0 kg/ha	100 kg/ha	200 kg/ha	300 kg/ha	
	..gram..				
2 : 1	27,60±0,30	25,63±0,97	25,63±0,58	27,87±1,09	26,68
3 : 1	27,03±2,20	26,23±1,35	26,03±0,17	27,33±2,08	26,65
4 : 1	24,90±0,58	24,97±1,00	23,67±1,18	26,87±0,53	25,10
Average	26,51	25,61	25,11	27,35	26,14
CV = 7,81 %					

Note: The numbers in the same row and column show no significant difference according to the F test at the 5% significance level.

Table 8 shows that the increase in the dose of Fertiphos fertilizer showed no significant difference in the weight of 1000 grains. Likewise, the variation of the JARWO rice planting system also showed no significant difference in the weight of 1000 grains. In general, the weight of 1000 grains of rice ranges from 23.67-27.87 g with an average weight of 1000 grains of 26.14 g. Based on the IBPGR-IRRI standard (1980), the characteristics of the weight of 1000 grains of rice are included in the heavy category. It is suspected that the results of the photosynthesis process in the form of dry matter are directly translocated to the panicle to fill the grains, so that a high weight of 1000 seeds can be obtained. These results are supported by the statement (Satria et al., 2017) which states that the weight of dry grain and the weight of 1000 grains of dry grain of a variety are greatly influenced by the number of productive tillers, plant height, and the number of grains per panicle. Sutaryo and Samaullah (2007) stated that the weight of the grain is greatly influenced by conditions after flowering, such as the condition of the leaves, the availability of photosynthate, and the weather. These factors will affect the amount of carbohydrates produced from the photosynthesis process, which will ultimately determine the size and weight of the rice grains. Billman (2008) emphasized that the weight of 1000 grains reflects the accumulated dry grain weight and the size of the grain, which depends on the size of the skin.

4. CONCLUSION

Based on the results obtained, it can be concluded that:

1. There is an interaction between the dose of Ferthipos fertilizer and the JARWO planting system on the growth and yield of black rice mutant rice, in the observation of the total number of tillers, the weight of filled grain per clump.
2. The dose of Ferthipos fertilizer 200 kg/ha showed the best results for the variable of the weight of filled grain per clump.
3. The JARWO 2:1 planting system showed the best results for the variable of the total number of tillers.

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