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Increasing The Growth and Yield of Lowland Rice (*Oryza Sativa* L.) with Optimum Dosage and Frequency of Potassium

Arman Effendi*, Sri Yoseva and Suningsih
Riau University,
Jl. Kampus Bina Widya KM. 12,5, Simpang Baru, Kec. Tampan,
Kota Pekanbaru, Riau 28293, Indonesia
*Email: arman.effendi@lecturer.unri.ac.id

ABSTRACT

Lowland rice is a commodity crop that is very influential in the survival of many people, especially inhabitants in most Asian countries, especially Indonesia. Rice is the staple food of Indonesian people, the shortage of which can result in complications for the country. In connection with this food security issue, it is necessary to make efforts to prevent food shortages. The national production capacity of rice must be increased. The long-term goal is to increase the productivity of rice plants to support Indonesia towards rice self-sufficiency. This study has a short-term objective, namely, to determine the effect of potassium fertilizer and to obtain the best dose on the growth and production of rice plants. This was a factorial experiment using a completely randomized design (CRD) with two factors: the KCl fertilizer dosage and the frequency of fertilizer application. The results showed that the best treatment was with a potassium fertilizer dosage of 150 kg ha-1 with a frequency of 2-time fertilizer application.

Keywords: *Oryza sativa L.; Dosage and Frequency System of Rice Intensification; Modification; Potassium Fertilizer*

1. INTRODUCTION

Field rice is a commodity crop responsible for people's sustenance in most countries, particularly Indonesia. It is a staple crop of Indonesian people who cannot run the risk of shortage as it potentially leads to conflicts. Considering its strategic importance regarding food security, Indonesia must avoid food shortages, especially rice. There is an increasing demand for rice, but the production capacity only sometimes meets the demand. The data issued by Badan Pusat Statistik (2018) shows that national rice production in 2017 was 81.38 tons, while in 2018, it was 56.54 tons. Furthermore, rice production in Riau province in 2017 was 365.73 tons of dry-milled rice; in 2018, it decreased to 365.29 tons. Seeing that the production capacity in the region experienced a decline from 2017 to 2018, increasing rice production is very important to fulfill the demand for rice.

To address this issue, efforts to increase rice production can be focused on intensification. One of them is the planting method known as SRI (System of Rice Intensification) can be utilized. Anugrah et al.(2008) stated that the SRI method could increase rice productivity and is more effective and efficient toward the environment than other, more conventional methods of planting rice. Water resource management and appropriate dosages of inorganic fertilizers can also increase rice productivity.

Astuti (2010) stated that water resource management significantly affects the plant height and number of tillers, and the weight of wet unmilled rice and dry unmilled rice and dry unmilled rice yield per hectare. The SRI method used on raised plots at 10cm from ground level produced up to 65 tillers, but the low productive yield at 50% was lower than the maximal tiller yield (Kasli & Effendi, 2012). A lack of trace elements and inappropriate timing for fertilizer application caused this. It is important that additional dosage of fertilizer, as well as proper timing for fertilizer, be monitored.

Giving a higher dose of fertilizer can increase the soil's fertility, affecting the total number of tillers, productive tillers, and branches in each panicle. If trace elements are insufficient, plant growth will be adversely affected and directly decrease the productivity of plants (Marzuki et al., 2014).

Potassium fertilizer is an essential element for increasing rice production. Potassium can strengthen the stem of a plant so it does not fall easily and protects it from pests and diseases (Zörb *et al.,* 2014). Farmers often use KCl as a source of K for plants, but many farmers use doses that do not match the needs of the plants. Asmin and Karimuna's research results (2014) by giving KCL 100 kg ha-1 can produce the highest grain.

2. MATERIAL AND METHODS

Location and Place

A field experiment was conducted at the Technical Implementation Unit of the Experiment Field Agriculture Department of Riau University Bina Widya Campus km 12.5 at Subdistrict Simpang Baru in the District of Tampan in Pekanbaru.

Materials and Tools

A rice variety, Batang Piaman, ultisol soil, compost, urea fertilizer, TSP fertilizer, KCl fertilizer, water, polybag, label, and insecticide known as Decis 25 EC were used. Other tools utilized were measuring tape, cleaver, curved cleaver, soil sifter, mesh, plastic bucket measuring 30 cm by 50 cm, hand sprayer, ruler, nursery box, digital scale, stationery, scissors, cutter or knife, rice polybag, stapler, and other documentation devices.

Research Methodology

The research was carried out experimentally using a complete randomized design (CRD) employing two factors: KCl fertilizer and frequency of application. Factor I (dosage of KCl) consists of K1 = 0.5g per polybag (100% of the recommended dosage of 100kg per 100 hectares), K2 = 0.75g per polybag (150% of the recommended dosage of 100kg per hectare), K3 = 1g per polybag (200% of the recommended dosage of 100kg per hectare). Factor II (frequency of fertilizer application) consists of P1= fertilizer is applied once during planting), P2 = fertilizer is applied twice while planting 30 DAP), and P3 = fertilizer is applied thrice during planting, 30 DAP and 60 DAP). Out of these two factors, nine combinations of treatments, out of which each combination of treatment was replicated three times resulting in 27 units of the experiment. Each unit of the experiment was carried out on 3 to 81 plants. The data obtained were analyzed statistically using Analysis of Variance. The effect of each combination of treatments was analyzed using Duncan's Multiple Range Test at 5%.

The Implementation of Research

The first step was to germinate rice seeds. Before the rice seeds were germinated, they were selected by soaking them for 24 hours. The seeds that sunk to the bottom were the ones chosen. Germination was done in a nursery box by broadcasting the seeds on a plant medium previously prepared in the nursery box at 13cm deep. The nursery box measured 60cm long, 30cm wide, and 15cm deep. The germination took 12 days to complete. Ultisol soil was obtained from the previously used soil in the rice fields located in Batu Belah Village from Kampar District in Kampar Regency. The soil was air-dried for three days, then sifted using a sifter measuring 25 mesh. After that, it was put in polybags and weighed 10kg in each bag.

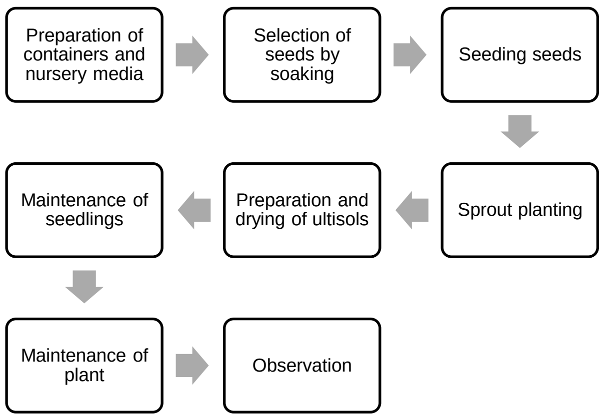

Figure 1. Research flow chart

Observation

The following parameters were monitored during observation:

- Plant height was measured four weeks after planting until the beginning of the generative phase.
- Crown root ratio observation was done seven weeks after planting.
- Maximum number of tillers, total number of tillers at the start of generative phase
- The number of productive tillers, counting tillers that produce panicles at each tassel, was carried out a week before harvesting.

- The emergence age of the panicle of a tassel was conducted by counting the number of days from planting until all sampling plants in 1 unit of experiment had shown tassel.
- We are harvesting age, from the day of planting to the day of harvest.
- The number of filled grains in each tassel was calculated by counting the average number of filled grains. The characteristic of filled grain is that the grain is very hard to break with fingernails and hard when pressed.
- The percentage of filled grain per tassel was calculated by dividing the number of filled gran in each tassel by the total number of grains (filled and hollow) multiplied by 100%.
- The weight of dry unmilled grain per tassel was observed by drying the grains from sample plants under the sunshine for 8 hours per day or three days until the water content reached ± 14%, which was later weighed using a digital scale.
- Weight of 1000 grains by taking 1000 filled grains randomly and weighing them using a digital scale.

3. RESULTS AND DISCUSSIONS

Plant Height

Variance analyses indicated that Kalium fertilization treatment did not significantly affect plant height. Meanwhile, the frequency of applying Kalium fertilizer treatment did not show significantly different results in plant height. Interactions of various doses and frequencies of Kalium fertilizer application showed significantly different results. Average plant heights after Duncan's New Multiple Range Test at 5% was performed are shown in Table 1.

Table 1. Average Plant Height of Field Rice of Batang Piaman Variety given K fertilizer application using SRI Modification Method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	94,65 b	90,38 ab	91,15 ab	92,06 a
K2	94,10 a	92,28 ab	94,05 a	93,47 a
K3	91,93 ab	94,43 ab	97,65 a	94,67 a
Average	93,56 a	92,36 a	94,28 a	

The table shown in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%

Table 1 indicates that interactions between K fertilizer at 200kg per hectare resulted in the highest plant at 97.65cm but did not show significantly different results from other treatments. Plant height is a characteristic that can contribute to rice plant growth. The higher the plant, the better the plant growth, indicating a conducive environment supported by the availability of trace elements and proper fertilizer management. Suprihatno (2010) proposed that plant height is influenced by the specific characteristics or indicators contributing to plant growth. With a long stem, the intensity of the sunshine, which can penetrate the canopy of plants to the soil below the soil surface, will also decrease. Awan *et al.*

(2014) also argued that taller plants use most of their photosynthates to develop stems and leaves compared to tillers in rice plants.

Crown Root Ratio

The analysis of variance showed that the application of K fertilizer had no significant effect on the maximum number of tillers. The average root crown ratio results after Duncan's New Multiple Range Test at a 5% level are presented in Table 2.

Table 2. Average Ratios of Rice Plant's Crown Roots of Batang Piaman Variant with K fertilizer application using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	3.07 ab	3.23 ab	3.05 ab	3.12 a
K2	3.05 ab	2.65 a	2.78 b	2.83 a
K3	2.87 b	2.83 ab	2.74 ab	2.81 a
Average	2.99 a	2.90 a	2.86 a	

The table shown in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%

Crown root ratios were derived by comparing the dry weight of the roots and the crown. The dry weight of the roots and the crown was determined after the root and crown parts were heated in an oven at 700C for 2 hours. The crown root ratio is a characteristic that can be used to assess oversupply or lack of trace elements that a plant can absorb. Excess water absorption can inhibit roots' growth rather than crown growth (Sulistyaningsih et al., 2005).

Pang et al. (2004) stated that waterlogging suppressed the development of roots rather than crown roots. K fertilizer treatment did not result in a significantly different crown-root ratio compared to other treatments. These results confirmed the results of a study conducted by Torey et al. (2013) that the crown root ratio could not be used to indicate insufficient water supply and trace elements in rice plants since they do not affect the crown root ratio.

The Maximum Number of Tillers

The results of variance analyses indicated that applying K fertilizer did not significantly affect the maximum number of tillers. The average number of the maximum number of tillers after performing Duncan's New Multiple Range Test at 5% is given in Table 3.

Table 3. Average maximum numbers of tillers of field rice of Batang Piaman variety with K fertilizer application using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	19,84 a	18,33 a	16,83 a	18,33 a
K2	16,16 a	20,05 a	17,33 a	17,85 a
K3	18,16 a	19,16 a	15,01 a	17,44 a
Average	18,05 a	19,18 a	16,39 a	

The table shown in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%

Table 3 shows that K fertilizer treatment at 150kg per hectare at a frequency of 2 repetitions resulted in the highest maximum tillers with 20.05. This is not significantly affected compared to other treatments. According to Husna

(2010), genetic and environmental factors, such as the adaptive environment, affect the character of a maximum number of tillers.

According to Lakitan (2008), the amount of trace elements required by a plant is related to the needs of the plant. A plant grows optimally if the amount available meets the plant's requirements. However, if the amount available is insufficient, the growth of a plant will be inhibited. A plant is considered deficient in trace elements if the availability is less than 80% of its optimal growth.

The Number of Productive Tillers

The results of variance analyses indicated that the maximum number of tillers was not significantly affected by K fertilizer treatment, whereas the number of productive tillers was significantly affected. Average ratios after performing Duncan's New Multiple Range Test at 5% were shown in Table 4.

Table 4. Average numbers of productive tillers of field rice of Batang Piaman variety with P and K fertilizer application using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	14.43 bc	12.11 ab	10.67 bc	12.43 a
K2	13.21 bc	15.56 bc	12.27 c	13.68 b
K3	11.22 ab	14.33 a	11.52 c	12.36 a
Average	12.95 b	14.00 a	11.49 c	

The table shown in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%

Table 4 indicates that the number of productive tillers in interactions between K fertilizer at 150kg per hectare at a frequency of 2 repetitions showed the highest result with 15.56. This result occurred as a result of excessive application of fertilizer, which can inhibit growth. Based on the observation, the number of productive tillers from all treatments decreased from the previous total number of tillers. This was probably caused by a large amount of rainfall, causing the water runoff to sweep the fertilizer away from the plants preventing maximal absorption of trace elements.

Emergence Age of Pannicle

The analysis of variance showed that the application of K fertilizer had no significant effect on the aging of the panicles. The average age of panicle exit after Duncan's New Multiple Range Test at a 5% level is presented in Table 5.

Table 5. The average age of emergence of a panicle of Batang Piaman rice variety with the application of K fertilizer using the SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	74.66 b	76.17 ab	74.56 b	75.13 a
K2	74.54 b	74.35 b	77.22 a	75.37 a
K3	75.78 ab	74.66 b	75.14 ab	75.19 a
Average	74.99 a	75.06 a	75.64 a	

The table shown in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%

Based on the results of analyses of variance, applying K fertilizer could increase the emergence age of panicles in rice plants. Interactions of treatment between K fertilizer at 150kg per hectare with a frequency of 3 repetitions resulted in the earliest emergence age of panicle at 77.22 days. However, this was similar to other treatments. The plant's genetic characteristic possibly causes this to adapt to the environment to which they respond similarly. Warda (2011) proposed that the emergence age of panicle is highly influenced by variety and strains known to have better adaptation toward the surrounding environment.

Harvesting Period

Results of variance analyses showed that applying K fertilizer did not significantly affect the harvesting period. The average harvesting periods of the plants after performing Duncan's New Multiple Range Test at 5% are given in Table 6.

Table 6. Average age of Harvesting Period of Batang Piaman rice variety with an application of K fertilizer using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	105.22 b	106.32 a	105.78 b	105.77 a
K2	105.12 b	106.77 ab	106.11 a	106.00 a
K3	105.56 ab	106.33 ab	106.44 ab	106.11 a
Average	105.30 b	106.43 a	106.11 a	

The table in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%.

Table 6 indicates that treatment of K fertilizer at 150kg per hectare showed the best outcome at 106.77 days. A good vegetative and generative phase can determine the harvesting period. The plant that showed earlier panicle would have an earlier harvesting period if the treatment did not have a significant effect. Masdar et al. (2006) stated that a plant would reach full maturity for harvest if the total energy absorbed has reached a certain limit. This varies from one plant to another due to their respective genetic makeup. The harvesting period is also influenced by the age at which the panicle emerges. According to Maisura (2001), the panicle flowering period's emergence period is closely related to the harvesting period, where a plant whose panicle emerges early will also have an early harvesting period.

The number of filled grains per panicle

Results of variance analyses showed that applying K fertilizer did not significantly affect the number of filled grains per panicle. The average number of filled grains per panicle after performing Duncan's New Multiple Range Test at 5% is given in Table 7.

Table 7. Average Numbers of Filled Grains of Batang Piaman rice variety with the application of K fertilizer using the SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	543.11 ab	567.56 a	452.21 bc	520.96 a
K2	425.33 c	414.11 bc	412.33 c	417.26 b
K3	511.22 a	623.44 a	341.00 bc	491.89 a
Average	493.22 a	535.04 a	401.85 b	

The table in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%.

Table 7 shows that observation on the number of filled grains in each panicle indicated that K fertilizer treatment at 150kg per hectare given twice resulted in the highest productive tiller at 623.44 and was significantly affected compared to other treatments. Trace element and water deficit during the initiation period of the panicle can result in a not fully developed panicle which can affect the future grains. The characteristic of the number of filled grains in a panicle is determined by the generative phase starting from the flowering and fertilization process (Mustikarini *et al.*, 2022).

According to Arshad *et al.* (2017), flowering and fertilization are important plant production periods determining grain content. This process is controlled by genetic and environmental factors, particularly growth and the resultant of photosynthesis. Genetic factors concern rice plants' ability to optimize grain content production by appropriately allocating photosynthesis results. In contrast, the environmental factor is connected with the smooth process of photosynthesis. The initiation period of panicle in rice plants is highly dependent on soil fertility. Trace element deficiency will adversely affect panicle development, resulting in the non-optimal development of grain. The number of grains is largely affected during the generative phase (Soemartono, 1984).

The percentage of Filled Grains per Panicle

Results of variance analyses indicated that K fertilizer treatment did not significantly affect the percentage of filled grain. The average results after performing Duncan's New Multiple Range Test at 5% are given in Table 8.

Table 8. Average Percentages of Filled Grains per Panicle of Batang Piaman rice variety with an application of K fertilizer using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	45.24 a	46.32 a	46.49 a	46.13 a
K2	46.48 a	45.87 a	46.52 a	45.14 a
K3	45.82 a	46.61 a	46.61 a	46.05 a
Average	45.31 a	46.23 a	45.77 a	

The table in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%.

Table 8 shows that the difference in K dosage and frequency of administration did not affect the percentage of rice grain. Healthy grain is determined by photosynthesis (carbohydrates) in the stems and leaves, which are then transferred and stored in the grain. That is, the percentage of rice grain does not show a response to the soil environment but is strongly influenced by genetic factors. Manalu et al. (2017) stated that the heritability value of the percentage of good grain was 70.6 (high), indicating that genetic factors are more dominant than environmental factors.

The Weight of Dry Milled Grain per Tassel.

Results of analyses of variance showed that K fertilizer treatment did not significantly affect the weight of dry milled grain per tassel. Average weights of dry milled grain in each tassel after performing Duncan's New Multiple Range Test at 5% are given in Table 9.

Table 9. Average Weight of Dry Milled Grains per Tassel of Batang Piaman rice variety with application of K fertilizer using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	20.47 ab	21.23 ab	20.63 ab	20.78 a
K2	20.77 ab	20.53 ab	19.83 b	20.38 a
K3	25.87 a	20.27 ab	19.83 b	21.99 a
Average	22.37 a	20.68 a	20.10 a	

The table in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%.

Table 9 shows that K fertilizer treatment did not significantly affect the weight parameter of dry-milled grains per tassel in the Batang Piaman rice variety. Interactions between the K fertilizer treatment at 200kg per hectare significantly differed from that of K fertilizer at 150kg per hectare. Still, they did not show a significantly different effect than other treatments. The most important process in the filling of grans is photosynthesis, which was thought to be the cause. This view aligns with Gardner (1991), who stated that photosynthesis occurring while filling the grain is the most crucial part of the final weight of the grains when harvesting. The reason for this is that before filling the grains, the results of assimilation are used in the vegetative state and development of flowers. Still, during the filling process, most of the assimilation products are mostly used for filling the grains. It is said that in connection to the maximum number of tillers, the higher the number of tillers produced, the higher the production of dry unmilled grains. Some conducive factors influencing the production of dry grains are tillers and the number of panicles formed.

The Weight of 1000 Filled Grains

Results of analyses of variance show that applying K fertilizer did not significantly affect the weight of 1000 filled grains. The average weights of 1000 filled grains after performing Duncan's New Multiple Range Test at 5% are given in Table 10.

Table 10. Average Weights of 1000 Filled Grains of Batang Piaman rice variety with an application of K fertilizer using SRI modification method

Kalium Fertilizer	Frequency of Application			Average
	P1	P2	P3	
K1	26.86 ab	26.74 ab	27.74 ab	27.12 a
K2	26.26 ab	29.40 a	25.14 b	26.94 a
K3	25.26 b	27.06 ab	27.86 ab	26.72 a
Average	26.12 a	27.74 a	26.92 a	

The table in the same columns and rows, followed by different small letters, denotes significantly different effects according to Duncan's New Multiple Range Test (DMNRT) at 5%.

Table 10 shows that the weight parameter of 1000 filled grains was not significantly affected by applying K fertilizer treatment in Batang Piaman variety rice plants. This is possible because the genetic factor has more impact on the size and shape of the grains than the environmental factor. Another probable factor is that the heritability of 1000 filled grains is considered low, and the weight of 1000 grains is relatively similar.

4. CONCLUSIONS

Giving different quantities of K fertilizer dosage demonstrates effects on some parameters, including productive tillers and the number of filled grains. Still, it does not affect plant height, the maximum number of tillers, crown root ratio, emergence age of panicle, harvesting period, the weight of grain per tassel, and weight of 1000 filled grains. The frequency of K fertilizer application affected parameters such as productive tillers, harvesting period, and the number of filled grains. Still, it needed to be more significant for other parameters such as plant height, the maximum number of tillers, crown root ratio, panicle emergence age, grain weight per tassel, and 1000 filled grains. Interactions of different doses and frequency of applying K fertilizer affect parameters such as plant height, crown root ratio, productive tillers, emergence age of panicle, harvesting period, number of filled grains, percentage of filled grains, the weight of dry milled grains per tassel and weight of 1000 filled grains but affects the maximum number of tillers. The most optimal treatment in this research was the application of K fertilizer at 150kg per hectare given in two repetitions.

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