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Use of Balanced Fertilizer Doses and Pruning Methods to Increase Growth and Yield of Rice Plants in Acidic Sulphate Lands in West Borneo

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ABSTRACT

The provision of appropriate technology for farmers was necessary to optimize the productivity of rice plants, especially in acidic sulfate fields. The purpose of study were to determine optimal dose of NPK fertilizer and right pruning time to increase growth and yield of rice plants in acidic sulfate fields. Research was conducted in acidic sulfate fields of Rasau Jaya Tiga village, Kubu Raya district, from August to December 2022. This experiment utilized a factorial randomized design group, with two factors namely: factor I and factor II. Factor I was NPK fertilizer (N): N1 = 0.9 kg/plot, N2 = 1.8 kg/plot, N3 = 2.7 kg/plot, N4 = 4.5 kg/plot. Factor II was leaf pruning (P): P0 = No Pruning, P1 = Pruning 30 days after planting (dap), P2 = Pruning 37 dap, P3 = Pruning 44 dap, P4 = Pruning 51 dap, and P5 = Pruning 58 dap. Observed variables were plant height, number of tillers, number of productive tillers, number of grains per panicle, amount of grain contained per panicle, and dry weight of grain per plot. Data were analyzed using F and Tukey tests at a 5% level of significance. The interaction of pruning treatment and NPK has an unsignificant effect on all observed parameters. NPK treatment and pruning singularly have a significant effect on all observed parameters. Pruning of the plant at 44 dap (P3) and NPK fertilizer dose of 4.5 kg/plot (N4) yielded the best results in all observed variables.

1. INTRODUCTION

Rice production in West Kalimantan has experienced a significant decline. Based on data from the West Kalimantan Central Bureau of Statistics, the decrease in rice production ranges from 50 to 60 thousand tons per year (BPS, 2022). The decline in rice production is considered a levelling-off condition, caused in part by a decrease in the quality of land resources (soil sickness) that affects productivity (Jamilah *et al*., 2016). Acid sulphate soils have the potential to replace fertile agricultural land that is continuously decreasing as one of the efforts to increase rice production to meet the food needs of the community

(Masulili *et al*., 2014). According to BPS data (2020), West Kalimantan has 1,904,100 ha (12.95%) of tidal land that has not been optimally utilized for agriculture.

The development of acid sulphate land for agriculture is faced with low availability of essential macro-nutrients such as N, P, and K, high solubility of elements that can poison plants such as Fe, Al, and Mn, and soil acidity that is generally acidic to very acidic (Masulili *et al*., 2014). The low fertility of the soil in acid sulphate land results in low rice production (Razie, 2019). According to Nazemi *et al*. (2012), the utilization of marginal acid sulphate swamp land for agriculture can be done through land management introduction with the use of balanced fertilizers, amelioration with lime, and other soil improvers. Noor *et al*. (2007) reported that the production of Ciherang rice planted in acid sulphate land was 3.75 tons of GKG/ha. Nursyamsi & Noor (2014) explained that the production of superior rice varieties in acid sulphate land varied from 3.0-5.1 tons of GKG/ha from several experiments conducted.

In addition, to increase rice production, pruning can be done during the maximum vegetative phase. Jamilah & Juniarti (2015) pruned Cisokan rice plants during the vegetative phase and caused twice the vegetative growth compared to non-pruned plants. Pruned rice plants are known not to affect the size and content of grains and can lower the height of the plant (Jamilah, 2018; Syah *et al*., 2021). Pruning treatment encourages plants to absorb nutrients from the soil as much as possible in a short time, causing the fertilizer given to not remain much in the soil. The use of appropriate doses of fertilizer (macro and micro-nutrients) and pruning treatments of assimilate shoot can cause fruit enlargement (Rehatta *et al*., 2014). These two treatments will interact in increasing rice plant productivity. Therefore, research needs to be conducted on pruning and balanced fertilizer application treatments on local rice varieties and acid sulphate land. This study aimed to obtain the optimal NPK fertilizer dose and the appropriate pruning time to increase the growth and yield of rice plants on acid sulphate land.

2. MATERIALS AND METHODS

This research was conducted in Rasau Jaya Tiga Village, Rasau Jaya District, Kubu Raya Regency, West Borneo Province. The research was carried out from August to December 2022. The materials used were Argo Pawan variety rice seeds, urea fertilizer, NPK fertilizer, SP-36 fertilizer, KCl fertilizer, herbicides, fungicides, insecticides and dolomite lime. The tools used in this study were sickles, scales, polybags, plastics, analytical scales, meters, and stationery.

2.1. Research Design and Data Analysis

This experiment utilized a factorial randomized design group, with 2 factors namely: factor I and factor II (Table 1). The determination of NPK fertilizer dosage was based on the research conducted by Razie (2019). To determine the effect of all treatments, an F -test at the 5% level was used. If there was a significant effect on the observed parameters, then it was compared using the Tukey test at the 5% level.

2.2.Stages of Research

2.2.1. Land preparation

The field before use was cleaned first of growing water weeds by being slashed and immersed in then the field is inundated with water for 1 day, then the soil was hoed 20 cm deep and behind then left for 2 days, after which the soil was hoed again until smooth and leveled then the water was removed until the soil condition is water-saturated. After the land was ready, a treatment plot of 40 m x 1.5 m (60 m^2) was made with a distance between plots of 50 cm (Maftuah & Hayati, 2019).

Table 1. Details of research factors

Factor I NPK Fertilizer (N)	Factor II Leaf Pruning
N1= 0,9 kg/plot	P0= No pruning
N2= 1,8 kg/plot	P1= Pruning 30 day after planting (dap)
N3= 2,7 kg/plot	P2= Pruning 37 dap
N4= 4,5 kg/plot	P3= Pruning 44 dap
	P4=Pruning 51 dap
	P5=Pruning 58 dap

2.2.2. Seeding seedlings

The seedbed land was hoed and smoothed after which it is fed with manure equivalent to 2 ton/ha (1 kg for a land area of 1 x 5 m). The condition of the seedbed land was made in “macak-macak” condition (a technique of providing water that aims to wet the land until it is saturated without being stagnant). Before the seeds were sown, the rice seeds were first soaked in running water for about 24 hours to accelerate the exit of the roots, after which the seedlings were evenly distributed in the seedbed, then watered with fine sand or manure until covered. The rice variety used was Argo Pawan rice (Salawati *et al*., 2021).

2.2.3. Liming

To reduce the level of soil acidification and solubility of Fe and Al, lime with a dose of 2 ton/ha or 12 kg/plot was carried out. Liming was carried out 2 weeks before planting (Salawati *et al*., 2021).

2.2.4. Basic Fertilization

Basic fertilization is carried out using phosphate fertilizer, namely Double Super Phosphate fertilizer with a dose of 50 kg/ha or 300 g/plot (Salawati *et al*., 2021).

2.2.5. Plant Seedlings

Seedlings were transferred to a field or experimental plot after 21 days after sowing (DAS) with a seedling count of 1 seedling per planting hole. Planting distance in experimental plots was 25 cm x 20 cm. When seedlings were planted to the experimental plot or during the vegetative phase, groundwater conditions are kept at a in a water-saturated position so that the development of roots and offspring is maximum (Salawati *et al*., 2021).

2.2.6. Fertilization

The fertilizer used consisted of two types Urea fertilizer and NPK fertilizer. The dose of urea fertilizer used with a dose of 100 kg / ha or 600 kg/plot was given twice, namely one week after planting and three weeks after planting. The dose of NPK fertilizer applied was by the treatment. The fertilizer used was NPK 16- 16-16. NPK fertilizer was applied 3 times with 1/3 dose each. The first application at 1 weeks after planting (WAP), the second at 3 WAP and the third at 6 WAP (Razie, 2019; Salawati *et al*., 2021).

2.2.7. Maintenance

The soil condition was maintained in a water-saturated condition during the vegetative growth period by regulating irrigation water, in the event of rain, a drainage channel is made so that the soil condition remains saturated with water. After the plant enters the ripening period, the grain/seeds of groundwater were reduced to airy capacity and dries. This drying aims to accelerate the simultaneous maturation of grains. Weed control was carried out by weeding the grass from the plant area after 3.6 WAP of age or before fertilizer application (Salawati *et al*., 2021).

2.2.8. Pruning

Leaf pruning was carried out according to the rice treatment carried out pruning. Rice leaves were pruned at a height of 15 cm from the ground (Jamilah, 2018).

2.2.9. Harvesting

Grain harvesting was done when the rice plant leaves have begun to turn yellow altogether or the yellow leaves had reached 90%. Only the flag leaves still look green (Salawati *et al*., 2021).

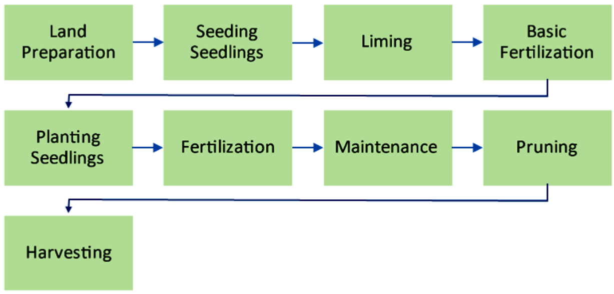

Figure 1. Research steps from land preparation to harvesting

2.3. Analysis for Soil Characteristic

Soil samples were collected in a composite manner from a depth of 0-30 cm. The samples were then sent to the Soil Laboratory of Tanjungpura University Pontianak. The soil nutrient parameters and analysis methods used were organic C (Walkley and Black), total N (Kjeldahl), calcium, magnesium, potassium, sodium, cation exchange capacity (CEC), and base saturation using the NH4OAC 1N extraction method, aluminum and hydrogen using the KCl 1N extraction method, pH (pH meter), as well as supporting data such as soil texture (pipette method).

2.4. Observation Parameters

The observed parameters in this study were plant height (cm), number of tillers, number of productive tillers, number of grains per panicle, number of grains contains per panicle, and dry weight of grain per plot done in the end of research.

3. RESULT AND DISCUSSION

3.1. Acidic Sulfate Land Characteristic

Based on the soil analysis in Table 2, it can be seen that the soil texture’s character is dusty clay. Soil texture is one of the physical properties of soil that can affect the chemical, physical and biological properties of the soil and plays a role in the penetration of plant roots and the ability to retain groundwater (Pusparani, 2018). Soil pH is one of the soil chemical reactions strongly controlled by the electrochemical properties of soil colloids, where pH can affect the provision of nutrients for plants

(Rahmah *et al*., 2014). Based on Table 1, soil pH in this study is 4.47, which is classified as very acid.

Table 2. Soil analysis result

Parameter Analisis	Value	Criteria
pH H_2O	4,47	Very Sour
pH KCl	4,00	
C-Organic (%)	17,94	Very High
Total Nitrogen (%)	1,16	Very High
Bray I Extraction		
P_2O_5 (ppm)	95,45	Very High
Extraction NH_4OAC 1N pH : 7		
Calcium (cmol (+) $^{kg-1}$)	2,74	Low
Magnesium (cmol (+) $^{kg-1}$)	2,03	Tall
Potassium (cmol (+) $^{kg-1}$)	0,57	Keep
Sodium (cmol (+) $^{kg-1}$)	0,54	Keep
KTK(cmol (+) $^{kg-1}$)	52,65	Very High
Alkaline Saturation (%)	11,17	Very Low
KCl 1N extraction		
Aluminum (cmol (+) $^{kg-1}$)	0,90	
Hydrogen (cmol (+) $^{kg-1}$)	0,71	
Texture		

Soil acidification occurs due to the presence of a pyrite layer (FeS_2) that undergoes oxidation (Khairullah & Noor, 2018). Several nutrients are not available in very acidic conditions. P will be fixed by iron phosphate, which is insoluble at a low pH, causing the availability of P to be very limited (Manurung *et al*., 2017). Rice is in dire need of the availability of macronutrients and micronutrients during the growth process (Zahrah, 2011). In addition to nutrient unavailability, plants can also experience Al and Fe poisoning due to the pyrite oxidation process, affecting rice growth (Shamshuddin *et al*., 2014). So that before the study liming was carried out to improve the chemical and physical properties of the soil. Several studies have proven that ameliorants can increase soil pH values, reduce Al and Fe toxicity, improve water content and soil permeability and increase nutrient availability (Gomez-Paccard *et al*., 2013; Gonzalo *et al*., 2013).

3.2. Rice Plant Growth and Yield

The summary of the analysis results of the diversity of observations on the growth and yield of rice plants with pruning and NPK fertilizer treatments can be seen in Table 3. The interaction between pruning and NPK treatments did not have a significant effect on all observation variables. The NPK and pruning treatments independently had a significant effect on all observed variables.

Table 3. Recapitulation of diversity analysis of the effect of NPK fertilizer pruning and dosage on observational parameters

Treatment	TT F. Hit	JA F. Hit	JAP F. Hit	JG F. Hit	JGB F. Hit	BKG F. Hit	F. Tab 5%
Pruning	5.16*	14.98*	2.60*	2.81*	2.72*	2.82*	2,42
NPK	18.55*	24.45*	18.71*	8.31*	8.34*	4.58*	2,81
Interaction	1.86^{TN}	1.23^{TN}	0.23^{TN}	0.33^{TN}	0.23^{TN}	0.16^{TN}	1,89

Description: TT = Plant Height; JA = Number of Tillers per Clump; JAP = Number of Productive Tillers per Clump; JG = Amount of Grain per Panicle; JGB = Number of Grains Containing per Panicle; BKG = dry weight of grain per plot; * = Significant Effect; TN = Not Significant Effect; F. Hit = F Count; F.Tab = F Table

3.2.1.Plant Height

Based on Table 3, the interaction between pruning and NPK treatments did not have a significant effect, but they had significant independent effects on the NPK fertilizer and pruning treatments. Furthermore, to determine the differences in the effects of NPK fertilizer and pruning treatments independently, a Tukey test was conducted at the 5% level, and the results can be seen in Tables 4 and 5.

Table 4. Tukey test 5% effect of pruning on plant height

Treatment	Average Plant Height (cm)
P0	87.08 b
P1	86.67 b
P2	86.75 b
P3	85.75 b
P4	84.17 ab
P5	80.92 a
BNJ 5%	3.42

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

According to Table 4, the P5 treatment showed the lowest plant height compared to the other pruning treatments. This is because the rice plants in the P5 treatment were pruned at 58 days after transplanting (DAT), which was already close to the rice's generative age. This is consistent with the study conducted by Jamilah *et al.* (2019), which showed that pruned rice plants resulted in lower plant height compared to non-pruned rice plants. According to Jamilah *et al.* (2016), rice plants require about 7-10 days for recovery after pruning. It is suspected that the nutrient uptake of rice plants in the P5 treatment was focused more on the generative phase, resulting in lower plant height compared to other treatments (Jamilah *et al.*, 2019). Meanwhile, in the P0 treatment, non-pruned plants showed the highest plant height (Jamilah *et al.*, 2019).

Table 5. Tukey test 5% effect of NPK fertilizer on plant height

Treatment	Average Plant Height (cm)
N1	82.06 a
N2	82.11 a
N3	87.83 b
N4	88.89 b
BNJ 5%	3.57

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Based on Table 5, the N3 and N4 treatments resulted in significantly different plant heights compared to the N1 and N2 treatments. The higher the dose of NPK fertilizer given, the higher the resulting plant height. This result is in line with the study conducted by Soplanit & Nukuhaly (2012), which showed that the application of NPK fertilizer has a significant effect on the height of rice plants. This can happen because of the relationship between the availability of nutrients and their absorption by rice plants, including N. The application of NPK fertilizer will cause a number of available nutrients to be absorbed by the plant as a source of energy. The higher and appropriate the application of NPK fertilizer on rice plants, the higher its effect on N uptake, so that the plant can optimally absorb nutrients for the growth and development of rice plants (Nuraini & Zahro, 2020).

3.2.2.Number of Tillers and Productive Tillers Per Clump

Based on Table 3, it was shown that the interaction between pruning treatment and NPK did not have a significant effect, but individually, the NPK fertilizer treatment and pruning treatment had a significant effect. To determine the difference in the effect of NPK fertilizer and pruning treatments independently, a Tukey test was conducted at a significance level of 5%, and the results can be seen in Tables 6 and 7.

Table 6. Tukey test 5% effect of pruning on the number of tillers and prductive tillers per clump

Treatment	Number of tillers per clump	Number of Productive Tillers Per Clump
P0	23.33 a	20.67 a
P1	24.42 a	21.17 ab
P2	25.17 ab	21.67 ab
P3	27.00 b	24.42 b
P4	26.58 b	24.33 b
P5	25.58 b	23.67 ab
BNJ 5%	2.07	3.43

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Based on Table 6, the P3 pruning treatment produced the highest number of tillers and productive tillers, but not significantly different from the other pruning treatments. Pruning is known to stimulate tiller growth (Harahap *et al.*, 2017). Although pruned rice plants will experience significant energy loss, they will still be able to produce new tissue (Jamilah *et al.*, 2019). Pruning is known to balance the nutrient needs, especially during the rice tillering stage, so it is presumed that the nutrients absorbed are more focused on tiller growth (Harahap *et al.*, 2017).

Table 7. Tukey test 5% effect of NPK fertilizer on the number of tillers and productive tillers per clump

Treatment	Number of Tillers per clump	Number of Productive Tillers Per Clump
N1	21.17 a	18.94 a
N2	25.11 b	20.94 ab
N3	26.72 b	23.22 b
N4	26.33 b	27.50 c
BNJ 5%	2.16	3.58

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Based on Table 7, the N4 treatment resulted in a significantly higher number of productive tillers compared to the other treatments. This is likely due to the increasing dose of NPK fertilizer applied to the soil, which provides more available nutrients for the plants and stimulates the growth of tillers. The number of tillers is greatly influenced by the availability of nitrogen and phosphorus in the soil (Nuraini & Zahro, 2020). A high availability of nitrogen will increase the rate of photosynthesis, while the addition of phosphorus will strengthen the plant's root system, resulting in the production of more tillers (Syahrudin *et al.*, 2021). Phosphorus also plays a role in cell division, so if there is enough available phosphorus, it can stimulate rice plants to produce more tillers (Sunadi *et al.*, 2019). If there is sufficient nitrogen in the soil, then the plant can produce more tillers (Iswahyudi *et al.*, 2018).

3.2.3.Amount of Grain and Grain Containing Per Panicle

According to Table 3, it shows that the interaction between pruning treatment and NPK fertilizer had no significant effect, but had a significant effect independently on NPK fertilizer treatment and pruning treatment. Furthermore, to determine the difference in the effect of NPK fertilizer and pruning treatment separately, a Tukey test was conducted at a 5% level of significance, and the test results can be seen in Table 8 and 9.

Table 8. Tukey test 5% effect of pruning on the amount of grain and grain containing per panicle

Treatment	Amount of Grain Per Panicle	Amount of Grain Contains Per Panicle
P0	77.11 a	61.69 a
P1	85.11 ab	68.09 ab
P2	90.89 b	72.71 b
P3	93.22 b	74.58 b
P4	93.22 b	73.96 b
BNJ 5%	7.93	6.75

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Based on Table 8, the P3 pruning treatment showed a significantly different number of grains and filled grains per panicle compared to the P0 treatment. According to the research conducted by Jamilah *et al*. (2016), rice plants that are pruned require around 7-10 days for the recovery process and the generation of reproductive parts. During the recovery process, the assimilate reserves in the stem decrease due to pruning, which leads to the absorption of nutrients by rice plants from the soil. In the P3 treatment, the rice plants were pruned at 44 days after transplanting, together with the third fertilization. It is suggested that the rice plants in the P3 treatment optimally absorbed nutrients after pruning, resulting in the highest number of grains and filled grains per panicle compared to the other treatments.

Table 9. Tukey test 5% effect of pearl npk fertilizer on the amount of grain and grain containing per panicle

Treatment	Amount of Grain Per Panicle	Amount of Grain Contains Per Panicle
N1	77.80 a	61.81 a
N2	89.47 b	71.73 b
N3	96.47 bc	77.07 bc
N4	101.47 c	81.55 c
BNJ 5%	8.72	6.14

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Based on Table 9, treatment N4 resulted in the highest number of grains and filled grains per panicle compared to the other treatments. This was thought to be due to the appropriate dosage of NPK fertilizer, which can increase the availability of N, P, and K in the soil and nutrient uptake by the plant. N, P, and K are essential nutrients required by rice plants for growth processes. Higher doses of NPK fertilizer can increase the average number of grains and filled grains per panicle, likely because NPK fertilizers can be directly absorbed by rice plants (Iswahyudi *et al*., 2018). According to Kaya (2013), nitrogen can increase the number of grains and filled grains per panicle. Adequate P in rice plants can increase metabolic activity in the soil, such as C and N assimilation, thereby increasing grain production (Jamilah *et al*., 2019).

3.2.4. Dry Weight of Grain Per Plot

Based on Table 3, the interaction between pruning treatment and NPK fertilizer did not have a significant effect, but each treatment individually had a significant effect on NPK fertilizer and pruning treatment. Furthermore, to determine the difference in the effect of NPK fertilizer and pruning treatment alone, a Tukey test was conducted at the 5% level, and the results are shown in Tables 10 and 11.

Table 10. Tukey test 5% effect of pruning on dry weight of grain per plot

Treatment	Dry Weight of Grain Per Plot (g)
P0	24.49a
P1	27.16ab
P2	27.88ab
P3	28.90b
P4	26.56ab
BNJ 5%	2.76

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

Table 11. Tukey test 5% effect of NPK fertilizer on dry weight of grain per plot

Treatment	Dry Weight of Grain Per Plot (g)
N1	26.11a
N2	27.17ab
N3	27.72ab
N4	28.89b
BNJ 5%	2.51

Note : Numbers followed by the same letter are not real in the 5% Tukey Test

According to Table 10, the pruning treatment P3 resulted in the highest dry weight of grains per plot and significantly differed from the P0 treatment. This is suspected to be due to pruning that can encourage rice plants to maximize nutrient absorption from the soil, thus increasing fertilizer efficiency. The assimilates produced in rice plants maximally stored in the form of grains after sufficient fertilizer application to the plant (Jamilah *et al*., 2016). Jamilah *et al*. (2014) stated that if plants obtain sufficient nutrients, the plant will grow optimally.

Based on Table 11, treatments N4, N3, and N2 resulted in significantly higher dry weight of rice grain per plot compared to treatment N1. According to Paiman & Ardiyanto (2019), the application of NPK fertilizer can enhance the process of photosynthesis in rice plants, thus increasing the formation of carbohydrates and proteins. The function of P as one of the constituent elements of proteins is needed for the formation of flowers, fruits, and seeds. Meanwhile, K plays a role in the process of metabolism, i.e., photosynthesis and respiration in plant growth. P is highly required by rice plants during the formation of the panicle, activating seed filling and accelerating seed maturation, while K is required by rice plants during the emergence of the panicle (Nuraini & Zahro, 2020).

Overall, pruning treatment does not affect the growth and yield components of rice plants. Pruning the plant canopy followed by the application of balanced fertilizers will spur an increase in the growth and yield of rice plants. In this study, pruning plant canopies at 44 dap and applying NPK fertilizer doses of 4.5 kg/plot showed the best results in all observed parameters.

4. CONCLUSION

Based on the research result, pruning the plant canopy at 44 days after transplanting and applying 4.5 kg/plot of NPK fertilizer can increase plant height, number of tillers, number of productive tillers, number of grains per panicle, number of filled grains per panicle, and dry weight of grain per plot of rice plants grown in acid sulfate soil as shown by the results of all observed variables.

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