Growth and Yield of Rice (Oryza sativa L.) Applied by Inorganic and Organic Fertilizer in Indonesian Tidal Soil

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Growth and Yield of Rice (*Oryza sativa* L.) Applied by Inorganic and Organic Fertilizer in Indonesian Tidal Soil

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Abstract: The aims of this study were to determine the dose of inorganic fertilizer of NPK combined with organic fertilizer from CM (Cow Manure) to grow paddy Inpara 8 variety planted in a tidal soil. This experiment was done in a green house and conducted from July to December 2020. This pot experiment used factorial completely randomized design with two factors and three replications. The first factor was NPK which consisted of two kinds of NPK fertilizers which were urea 200 kg/ha, SP-36 100 kg/ha, KCl 100 kg/ha from recommended fertilization and urea 37 kg/ha, SP-36 56 kg/ha, KCl 183 kg/ha from calculation of the specific location soil analysis (in situ data). The second factor was dosage of CM at 5, 7.5 and 10 tons/ha respectively. The results showed that NPK fertilization from specific location combined with CM at 10 tons/ha was the best treatment for rice production in an infertile tidal swampland producing 2.20 tons/ha.

Key words: Inorganic fertilizer, CM, NPK specific location, rice and tidal soil.

1. Introduction

Rice is a very important staple food in South East Asia, primarily in Indonesia [1]. In 2021, Indonesia has a population around 271,34 million and they are consuming the rice daily. To fulfill this need, 36.6 million tons of rice are required each year with the assumption of rice requirement about 135 kg/capita/year. Based on data [2], rice cultivation in South Sumatra in 2018 had harvested area of 581,574.61 ha with the productivity of 5.14 tons/ha producing 2,994,191.84 tons. The declining rice production occurred in 2019 due to decreasing harvested area down to 539,316.52 ha. If the rice productivity was 4.82 tons/ha, thus the rice yield was 2,603,396.24 tons. The declining in harvested area was causing the decreasing rice production, thus it can be anticipated by optimizing the soil resources. According to Haryono [3], one of the available soil resources that have not been utilized optimally is tidal soils or swampy soils. This tidal soil is derived from fine marine sediment that contains sulfidic materials, popularly called "pyrite" [4]. This characteristic is causing this soil has low pH combined with low fertility [5]. This poor soil fertility was producing low rice productivity [6]. Thus, an increase in rice production can occur if this poor soil fertility shown by tidal soils can be improved [7]. Tidal land is one of the lands that have potential for rice cultivation that has long been developed by the government for 40 years ago. Based on data [8], Indonesia has a tidal land area of about 23.10 million ha and in South Sumatra covered about 961,000 ha.

Rice planted in tidal soils could have high productivity if the soil is managed properly and the inputs applied in sufficient and appropriate it. The main factor in the management of this tidal soil for rice

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growth is fertilizer application. The dose of fertilizer given follows the type of variety used and type of fertilizer applied [9]. Based on Bustami et al. [10], the important role of nutrients for tidal soil is phosphate that is available at the time of rice planting. This is related to the ability to form clumps/tillers supporting rice production. In addition to N and P elements, K element is also needed for rice growth. The K^+ ions that have function as activators of many enzymes play a role in plant metabolism [11]. Organic fertilizer such as CM (Cow Manure) is very important for crop growth by supply nutrient. CM is bio-organic material produced from the combination of cow feces and urine [12]. This cow manure can also improve soil structure and increase the availability of some nutrients [13]. Increasing the dose of cow manure has an effect on increasing soil pH, because CM is alkaline with pH more than 8.00 [5, 12]. The OH^- ion activity of the carboxyl ($COOH^-$) and hydroxyl (OH^-) groups increases soil pH due to the presence of decomposed organic matter [9]. The cow manure at a dose of 5 tons/ha gave the best results of 1,000 grains weight and producing 4.04 tons/ha [14].

Hatta and Sulakhudin [15] reported that the fertilization rate must be adjusted to the nutrient status in soil. Site-specific fertilization is required as a balanced and rational fertilization effort based on plant nutrient requirements at site-specific location [16]. Thus in this experiment, the dose of NPK was calculated from in situ soil NPK based on the requirement of NPK compared to NPK recommendation combined with local cow manure.

2. Material and Methods

This pot experiment was conducted from July until December 2020 in the Greenhouse of Department of Soil Science, Faculty of Agriculture, Sriwijaya University. Soil sample was taken from arable layer of “A” typology at Mulia Sari Village, Tanjung Lago, Banyuasin Regency with coordinate of 02°25′20″ S and 104°25′20″ E. The materials used in this experiment were soil sample from tidal land, Inpara 8 paddy variety, inorganic NPK fertilizer and local cow manure. The initial soil properties were analyzed which were pH, N, P, K, Na, Ca, Mg, soil Cation Exchange Capacity (CEC), Al and H exchangeabilities and soil texture. The calculation of site-specific NPK fertilizer requirements for rice plants is determined by the values of soil N-total, P-Bray and K-exchangeable appeared which were used as a reference for calculating site-specific fertilizer requirements.

2.1 Research Design

This experiment was performed using a factorial completely randomized design with two factors. The first factor was NPK fertilizer which consisted of two kinds of NPK which were recommended dose of NPK fertilization with the rate of urea 200 kg/ha, SP-36 100 kg/ha, KCl 100 kg/ha and NPK based on soil analyzed in situ which was urea 37 kg/ha, SP-36 56 kg/ha, KCl 183 kg/ha. The second factor was application of cow manure at three levels which were 5, 7.5 and 10 tons/ha respectively. The data observed were analyzed using *F* test and further tested using LSD (Least Significant Difference) at 5% level.

2.2 Fertilization

The cow manure was applied two weeks before planting. After that, urea was given in three times, namely at the beginning of planting, 14 DAP (days after planting), and 28 DAP. The application of SP-36 and KCl fertilizers was broadcasted at the time of planting.

2.3 Seedling and Planting

The paddy seeds cultivated were rice seeds of the Inpara 8 variety. The seeds were sown using trays with a planting medium in the form of a mixture of soil, sand, and cow manure (1:1:1). After that the seeds were sown on the media and kept moist until germination and grew well. After 2 weeks of the seedling, then the young plants were transferred to the planting medium in the form of soil that has been prepared previously. The soil treatment was conditioned in the moist but not flooded. Planting was done as much as one crop in each pot. The variables observed in this experiment were plant height, maximum number of tillers, number of productive tillers, weight of 1,000 grains, weight of grain clumps, percentage of pithy weight, rice production, and soil analysis after harvesting. Harvesting of plants was done when the age of the plant was in accordance with the description of the age of the variety, which was 115 days.

3. Results and Discussion

3.1 Tidal Soil Characteristics Used for Experiment

The soil used for this experiment was tidal soil from A typology (flooded at high and low tide). The characteristics of the soil before planting rice is presented in Table 1. As shown in Table 1, the tidal soil was classified into acid sulfate soil with very low pH amounting to 3.73 [4]. This very acidic soil had low and very low basic cations except for sodium. Sodium in this soil has high content coming from water sea.

Very high organic matter with value of 6.10%, low of K^+ and Mg^{2+} with value of 0.38 cmol(+)/kg and 0.41 cmol(+)/kg respectively were found, meanwhile Ca^{2+} exchangeability with value of 1.74 cmol(+)/kg was very low content. The almost similar result of characteristic of tidal soil was found by Budianta et al. [5]. In addition, the exchangeability aluminum was 1.15 cmol(+)/kg and low CEC with value of 15.23 cmol(+)/kg was found except for P availability. The Bray-P availability was very high content due to long term cultivation for more than 40 years and saturated P was stayed in soil linked by amphoteric ions (such as Al, Mn and Fe). Based on the basic cations content and pH, it indicates the infertility tidal soil and requires the improvement of the soil fertility to grow rice crop. The input which can be applied is inorganic and organic fertilizer.

3.2 Tidal soil Characteristics after Harvesting

Analysis of variance after harvesting is presented in Table 2. From the table it was shown that the NPK fertilizer had a very significant effect on soil pH and K exchangeability but had no significant effect on the variables of N-total and P-availability. Meanwhile cow manure application had very significant effect on the K exchangeability but had no significant effect on other variables. Meanwhile the interaction of NPK fertilizer and cow manure showed no significant effect on all variables observed.

Table 1 Some soil characteristics of tidal soil.

Variable	Unit	Result*	Criteria**
pH H_2O (1:1)		3.73	Very acid
C-organic	%	6.10	Very high
N-total	%	0.39	Medium
P-availability (Bray I)	mg/kg	15.50	Very high
K-exch	cmol(+)/kg	0.38	Low
Na-exch	cmol(+)/kg	0.90	High
Ca-exch	cmol(+)/kg	1.74	Very low
Mg-exch	cmol(+)/kg	0.41	Low
CEC	cmol(+)/kg	15.23	Low
Al-exch	cmol(+)/kg	1.15	Very low
H-exch	cmol(+)/kg	0.56	
Particle distribution			
Sand	%	46.03	
Silt	%	29.67	
Clay	%	12.71	
Texture			Loam

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** Soil Research Institute [17].

Table 2 The *F* test and coefficient of variation of the effect of NPK and cow manure on some soil chemical properties after growing rice.

Variable	*F* test			CV (%)
	A	B	A×B	
1. pH H_2O	13.61^{**}	1.52^{ns}	0.21^{ns}	2.05
2. N-total (%)	0.15^{ns}	1.87^{ns}	0.47^{ns}	16.62
3. P-availability (mg/kg)	0.19^{ns}	1.23^{ns}	0.28^{ns}	12.24
4. K exchangeability (cmol/kg)	42.39^{**}	9.50^{**}	0.93^{ns}	16.31

* = Significantly effect, ** = Very significant effect, ns = nonsignificant, A = application of NPK, B = application of cow manure, A×B = Interaction of NPK fertilizer and cow manure, CV = Coefficient of variance.

3.3 Effect of NPK Application on Some Soil Chemical Properties after Harvesting

Table 3 shows that soil pH after harvesting when compared with before rice planting showed that application of NPK recommendation (A_1) increased 0.06 unit but small increasing about 0.08 unit when NPK of site-specific fertilizer (A_2) was added. Even though the recommended dose of NPK fertilizer increased by 0.06 unit, the average soil pH obtained for both treatments of NPK fertilizer was still in very acidic condition. Based on Kaya [18], application of NPK can reduce soil pH because NPK contains 10% sulfur. The sulfur will be reacting with water, oxygen, and CO_2 molecules in the soil producing sulfate ion and H^+ ion causing the soil pH decreases.

Total soil nitrogen after harvesting decreased by 0.10% and 0.11% for the treatment of the recommended dose of NPK fertilizer (A_1) and site-specific (A_2) respectively. The results of LSD test showed that A_1 was not significantly different from A_2. Damanik et al. [19] stated that the decrease of total N in soil was caused by nitrogen lost in the form of gases (N_2, N_2O, NO and NH_3), losses due to leaching and loss of nutrients at harvesting. This nitrogen content is not only needed for plant growth but is also useful in the formation of new cell in plant.

The soil phosphorus availability content after harvesting when compared to before rice planting increased by 12.57 and 13.30 mg/kg respectively for the recommended dose of NPK fertilizer (A_1) and site-specific (A_2) respectively (Table 3). According to Kuncoro [20], the increase in available P content in the soil was due to the application of SP-36 fertilizer which contains high P_2O_5 which is 36% and the reaction process is quickly available in the soil thus it will be able to supply and increase P content in the soil.

Meanwhile the soil K exchangeability after harvesting increased by 0.64 and 1.32 cmol(+)/kg respectively for the treatment of the recommended dose of NPK fertilizer (A_1) and site-specific (A_2). The results of the LSD test showed that K exchangeability was affected by the application of NPK. The increase of K exchangeability in the soil after harvesting can occur due to the nature of NPK fertilizer that are easily soluble in water and the 60% K_2O content from fertilizer will dissolve in the soil and produce K^+ cation in solution [18].

3.4 Effect of Cow Manure Application on Soil Chemical Properties after Harvesting

The application of cow manure had a very significant effect on the K exchangeability but had no significant effect on other variables (Table 4). Based on the result of the analysis presented in Table 4, it shows that the pH of the soil after harvesting when compared with before the experiment shows that the application of cow manure has not been able to increase soil pH significantly. The highest soil pH was found in the treatment of cow manure at 10 tons/ha although increasing only 0.02 cmol(+)/kg. This is due to the fact that the soil pH can increase following the increase of the dose of cow manure. According to Fikdalillah et al. [21] the increase of the pH along with the increase in cow manure was caused by the release of OH^- ion and the release of organic acids contained in the cow manure. Bugis [22] also explained that the application of cow manure can increase pH.

Table 3 Effect of NPK on some soil chemical properties after harvesting.

Variable	Unit	Result of initial soil	Results of soil analysis after harvesting		LSD (0.05)
			Recommended rate (A_1)	Site specific rate (A_2)	
pH H_2O		3.73	3.79^a	3.65^b	0.07
N-total	%	0.39	0.29^a	0.28^a	0.04
P availability	mg/kg	15.50	28.07^a	28.80^a	3.57
K exchangeability	cmol/kg	0.38	1.02^a	1.70^b	0.22

The same letter in the same column means not significant difference in 5% LSD test.

Table 4 Effect of cow manure application on soil chemical properties after harvest.

Variable	Unit	Result of initial soil properties	Result of soil analysis after harvesting			LSD (0.05)
			5 tons/ha (B_1)	7.5 tons/ha (B_2)	10 tons/ha (B_3)	
pH H_2O		3.73	3.68[a]	3.73[a]	3.75[a]	0.09
N-total	%	0.39	0.25[a]	0.30[a]	0.30[a]	0.06
P-availability	mg/kg	15.50	28.07[a]	27.07[a]	30.16a	4.37
K-exchangeability	cmol/kg	0.38	1.05[b]	1.60[a]	1.44[a]	0.28

The same letter in the same column means not significant difference in 5% LSD test.

This is due to the fact that the CM will be further decomposed or mineralized releasing some basic cations such as Ca^{2+}, Mg^{2+}, Na^+, K^+ which cause the concentration of OH^- ion increase resulting in the pH increase.

Total soil nitrogen after harvesting decreased by 0.14%, 0.09%, and 0.09% respectively for the treatment of cow manure at 5 tons/ha (B_1), 7.5 tons/ha (B_2) and 10 tons/ha (B_3) (Table 4). It means that B_1 was not significantly different compared to B_2 and B_3. Based on the research of Bachtiar et al. [23], the dose of cow manure at 15-20 tons/ha was proven to increase the total N of plant significantly because high doses of manure caused a reduction in N loss through leaching. The higher the dose of cow manure, the higher the N nutrient uptake for crop. This shows that the total N content of the soil after harvesting decreases because the N in the soil has been absorbed by rice and distributed during rice growth.

The phosphorus availability in the soil after harvesting increased by 12.57, 11.57 and 14.66 mg/kg respectively for the treatment of cow manure at a dose of 5 tons/ha (B_1), 7.5 tons/ha (B_2) and 10 tons/ha (B_3). The highest increase in available P content was obtained from treatment B_3 then followed by B_1 and B_2. This is due to the higher dose of cow manure, the higher the available P. This statement is in accordance with the results of Jeksen [24] that the highest P availability content, namely 56.17 mg/kg was obtained at 40 tons/ha cow manure treatment or 55.97% higher than P availability content in the treatment without cow manure.

Soil kalium exchangeability after harvesting increased by 0.67, 1.22, and 1.06 cmol(+)/kg respectively for the treatment of cow manure at 5 tons/ha (B_1), 7.5 tons/ha (B_2) and 10 tons/ha(B_3). Kalium exchangeability was affected by the application of cow manure, showing that B_1 was significantly different from B_2 and B_3. The increase in kalium is in line with the research of Rostaman et al. [25] that the application of organic matter to paddy fields can increase the exchangeable K^+ by 1.02 cmol(+)/kg through the decomposition of organic matter. This causes potassium to be available in the paddy soil and not easily leached.

3.4.1 Rice Growth and Yield

The NPK treatment had a very significant effect on plant height (except for 2 WAP (Week after Planting) and 4 WAP), maximum number of tillers, and the number of productive tillers. Meanwhile, cow manure had a very significant effect on almost all variables except for plant height at 2 WAP and 4 WAP. The interaction of NPK and cow manure application had no significant effect on almost all variables except for plant height at 6 WAP and 12 WAP, percentage of pithy (Table 5).

3.4.2 Plant Height

Plant height is an essential trait for plant because it is related to plant growing [26]. The results of the analysis of diversity showed that the application of NPK significantly affected plant height variable except at 2 WAP and 4 WAP. Plant height at 12 WAP was higher in A_2 compared to A_1. In this regard the plant height was affected by NPK fertilizer but treatment of A_2 was not significantly different from A_1 at the 2 WAP and 4 WAP. Meanwhile, plant height was affected by NPK fertilizer at 6 WAP, 8 WAP, 10 WAP and 12 WAP (Table 6).

Table 5 The *F* test and coefficient of variation of the effect of NPK and cow manure on growth and yield of rice.

Variable	*F* test A	*F* test B	*F* test A×B	CV (%)
1. Plant height (cm)				
2 WAP	0.44^{ns}	1.99^{ns}	0.45^{ns}	7.16
4 WAP	0.02^{ns}	0.41^{ns}	0.35^{ns}	6.95
6 WAP	8.47*	15.15**	6.00*	6.52
8 WAP	5.66*	34.56**	0.45^{ns}	1.53
10 WAP	109.22**	91.03**	1.50^{ns}	2.88
12 WAP	242.59**	145.16**	12.00**	2.65
2. Max numbers of tillers	82.57**	90.93**	1.36^{ns}	5.96
3. Productive number of tillers	34.24**	24.52**	2.30^{ns}	12.62
4. Weight of 1,000 grains (g)	0.85^{ns}	4.11*	0.86^{ns}	23.58
5. Weight of grain per clump (g)	1.34^{ns}	47.16**	1.10^{ns}	16.09
6. Percentage of pithy grain (%)	0.08^{ns}	5.44*	4.12*	5.78
7. Grain production per ha	1.22^{ns}	37.61**	0.52^{ns}	19.65

* = Significantly effect, ** = Very significant effect, ns = nonsignificant effect, A = NPK fertilizer, B = Cow manure, A×B = Interaction of NPK and cow manure, CV = Coefficient of Variant.

Table 6 Effect of NPK fertilizer and cow manure on plant height.

Variable	NPK fertilizer (A)	Cow manure (B) B_1	B_2	B_3	Main A
Plant height at 12 WAP	A_1	71.20^{a}	83.67^{a}	102.90^{a}	85.92^{a}
	A_2	96.70^{b}	102.53^{b}	114.13^{b}	104.45^{b}
Main B		83.95^{a}	93.01^{b}	108.51^{c}	
LSD 5% A = 2.59, B = 3.17					

The same letter in the same column means not significant difference in5% LSD test.

The application of NPK fertilizer can increase plant height growth, especially nitrogen fertilizers which can accelerate the vegetative growth of rice plant. This is in line with the research result of Iswahyudi et al. [27] which showed that the height of rice plant at a dose of 400 kg/ha was significantly different from the treatment at a dose of 300 kg/ha, 200 kg/ha and the control treatment.

Plant height affected by cow manure showed that A_2 was not significantly different from A_1 at the time of observation of 2 WAP and 4 WAP. Meanwhile, plant height was affected by cow manure application at the time of observation of 6 WAP, 8 WAP, 10 WAP, and 12 WAP, showing that A_2 was significantly different from A_1. In line with the research results of Tufaila et al. [28] at the age of 2 and 3 WAP the effect was not significant, but at plant height 4 WAP and 5 WAP the bokashi treatment of cow dung had a very significant effect. This is because the nutrients contained in cow manure cannot be directly absorbed by paddy plants because it takes time to decompose completely so that the nutrients contained in cow manure can be absorbed by plants.

The interaction of NPK fertilizer and cow manure (Fig. 1) on plant height variables increased every week. The plant height with the best treatment was shown in A_2B_3 treatment which was 114.13 cm and the worst treatment in A_1B_1 treatment was 71.20 cm at 12 WAP observations.

3.4.3 Maximum and Productive Tillers

A tiller is a stem produced by a rice crop and refers to all shoots that grow after the initial parent shoot grows from a seed, and maximum tillers are the total of tillers grown during rice growth [5]. The results of the analysis of diversity showed that the application of NPK fertilizer and cow manure had a significant effect on the maximum number of tillers and the number of productive tillers. Aksani et al. [29] also found that NPK fertilizer significantly affected the maximum tiller of INPARA 4.The maximum number of tillers and productive tillers with the best treatment were shown in treatment A_2. A productive tiller is a stem produced by a rice crop beside the main stem yielding grain. The number of productive tillers is determined by the number of tillers that grow before the primordial stage [5]. The maximum number of tillers and productive tillers were affected by the application of NPK fertilizer, showing that A_2 was significantly different from A_1 (Table 7). The treatment of A_2 produced higher maximum and productive tillers compared with $A_1$with value of 16.67 and 16.11 respcetively. This is in line with the results of Kaya [18] where the higher the level

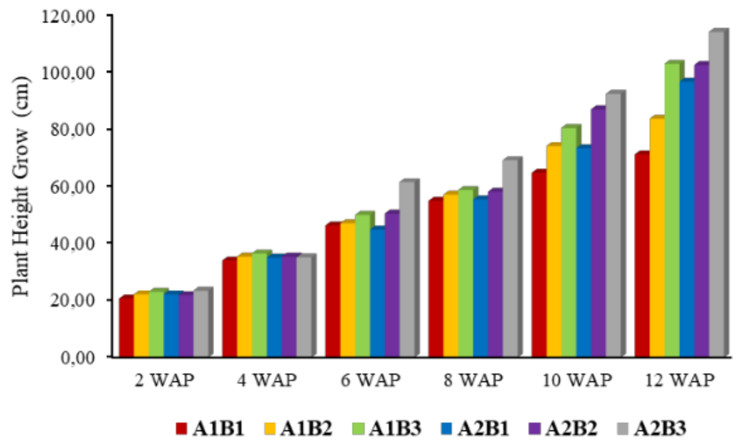

Fig. 1 Interaction effect of NPK and CM on plantheight.

Table 7 Effect of NPK and CMon tillers growth.

Treatment	Variables	
	Maximum number of tillers (stem/clmp)	Number of productive tillers (stem/clmp)
Influence of NPK		
A_1 (Recommended)	12.89^b	11.33^b
A_2 (Location specific)	16.67^a	16.11^a
LSD (0.05)	0.90	1.79
Influence of cow manure		
B_1 (5 tons/ha)	11.16^c	10.67^c
B_2 (7.5 tons/ha)	15.16^b	13.83^b
B_3 (10 tons/ha)	18.00^a	17.16^a
LSD (0.05)	1.10	2.17

The same letter in the same column means not significant difference at 5% LSD.

of treatment given the dose of NPK fertilizer, the higher the number of productive tillers. Harjadi [30] explained that cereal plants require N and K nutrients that can stimulate the photosynthesis process to enter the generative phase, especially for the formation of tillers that produce panicles.

Cow manure application also showed that A_2 was significantly different from A_1 on the variable number of maximum and productive tillers (Table 7). Based on Kaya [18] the effect of compost at 3 ton/ha on the variable number of productive tillers resulted in 27.96 significantly different compared to without compost which only produced 25.29. The highest maximum and productive tillers were found by application of CM at 10 tons/ha. Menawhile the application of NPK fertilizer and cow manure can increase the vegetative growth of rice crop at the maximum number and productive of tillers.

The interaction of NPK fertilizer and cow manure had no significant effect on the maximum number and production of tillers but increased every week. The maximum number of tillers with the best treatment was shown in the A_2B_3 with value of 20.33 and the A_1B_1 produced lowest maximum of tillers with value of 9.67 (Fig. 2). While the number of productive tillers with the best treatment was shown in the A_2B_3 with value of 20.33 and lowest productive tiller with value of 9.00 was found at A_1B_1 treatment (Fig. 3).

3.4.4 1,000-Grain Weight

Thousand-grain weight obtained varied from 33.05 to 46.13 g, and the highest 1,000-grain weight with value of 46.13 g was obtained at CM application at the rate of 10 tons/ha (Table 8). The treatment of NPK fertilizer resulted in the highest weight of 1,000 grains found in the treatment of site-specific dose of NPK fertilizer (A_2) with value of 39.59 g while the lowest weight of 1,000 grains was obtained in the treatment of recommended of NPK fertilizer (A_1) producing 35.73 g

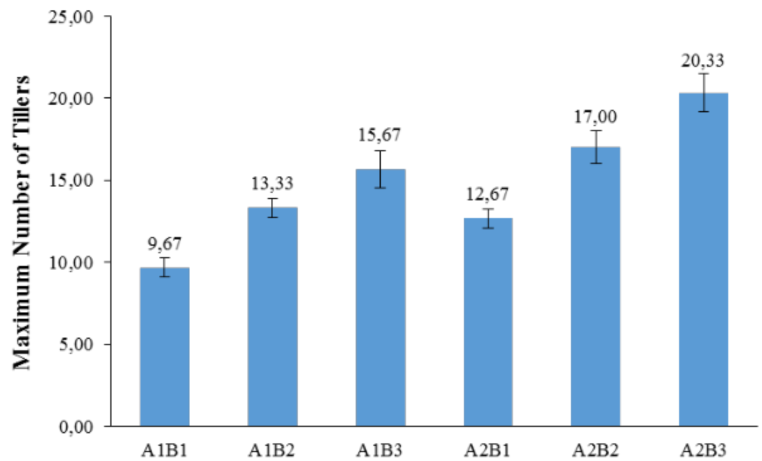

Fig. 2 Interaction effect of NPK and CM on the number of máximum tillers.

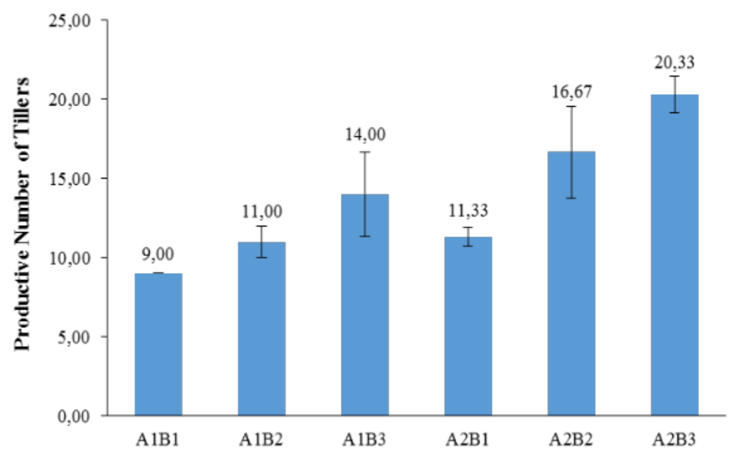

Fig. 3 Interaction effect of NPK and CM on the productive tillers.

(Table 8). Increased yields of rice can occur if the elements of NPK can be met. This is supported by the statement of Siti [31] that the fulfillment of the needs of NPK elements causes increasing vegetative growth, photosynthesis and photosynthetic translocation to take place optimally. Grain weight is really influenced by N and P nutrients, affecting the size of lemma and palea. The weight of more than 1,000 grains is determined by the shape of the grain [32].

The treatment of CM (Cow Manure) resulted in the highest weight of 1,000 grains found in the treatment with a dose of 10 tons/ha (B_3) with value of 46.13 g while the lowest weight of 1,000 grains was found in the treatment of CM with a dose of 5 tons/ha (B_1) producing 33.05 g (Table 8). This is because the treatment with CM is able to stimulate the panicle initiation period so that it can increase the amount of grain. In addition to the availability of nutrients, the formation of seeds in grain also requires the role of water. According to Rahmiati and Mawaddah [33] the weight of 1,000 of grain will increase if the availability of ground water is maintained during the crop growth process.

Table 8 Effect of application of NPK and CM on rice yield.

Treatment	Variables Observed			
	Weight of 1,000 grains (g)	Grain weight per clump (g)	Percentage of pithy grain weight (%)	Grain production per ha (ton/ha)
Influence of NPK				
A_1(Recommended)	35.73^a	10.78^a	84.03^a	1.46^a
A_2 (Location Specific)	39.59^a	11.77^a	83.37^a	1.61^a
LSD(0.05)	9.12	1.86	4.97	0.31
Influence of cow manure				
B_1 (5tons/ha)	33.05^b	5.60^c	78.92^b	0.70^c
B_2 (7.5 tons/ha)	33.79^b	12.76^b	84.06^{ab}	1.72^b
B_3 (10tons/ha)	46.13^a	15.46^a	88.12^b	2.18^a
LSD(0.05)	11.17	0.80	6.09	0.38

The same letter in the same column means not significant difference at 5% LSD test.

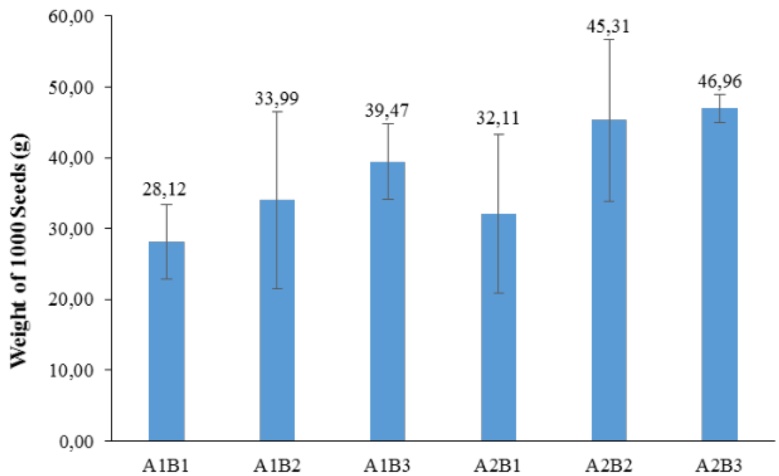

Fig. 4 Interaction effect of NPK and CM on the weight of 1,000 grains.

The interaction of NPK and cow manure had no significant effect on the 1,000 grains weight. However, the best treatment was shown in A_2B_3 treatment of 46.96 g and the lowest of the 1,000 grains weight was found at A_1B_1 treatment with value of 28.12 g (Fig. 4). The high weight of 1,000 grains which does not match the description of Inpara 8 paddy seeds, which is 27.2 g, is due to the fact that at the time of measurement, the grain has not yet reached 14% moisture content. According to Pradipta et al. [34], the yellow maturity level of all panicles produces the maximum weight of 1,000 grains, because in this phase the filling of the rice grains is fully developed and the accumulation of food reserves in the seeds reaches the maximum.

3.4.5 Weight of Grain per Clump

The highest grain weight variable per clump was found in the treatment with the site-specific dose of NPK fertilizer (A_2) with value of 11.77 g, while the lowest grain weight per clump was obtained at the recommended dose of NPK fertilizer (A_1) with value of 10.78 g (Table 8). Increased yields in rice plants can occur if the elements of NPK can be met. This is supported by Siti [31] who explains that the fulfillment of the needs of NPK elements causes vegetative growth, photosynthesis and photosynthetic translocation to take place optimally.

The treatment of cow manure resulted in the highest grain weight per clump in the application of cow manure at 10 tons/ha (B_3) with value of 15.46 g while the lowest grain weight per clump was found at cow manure with a dose of 5 tons/ha (B_1) with value of 5.60 g (Table 8). One of the common problems encountered in acid-sulfate soils is the high P fixation by Al and Fe resulting in low crop yields. However, the application of cow dung can suppress Al and Fe nutrients and can increase the availability of other nutrients such as N, P, K and Ca which are needed by plants to increase production. This is in line with the research results of Sudianto et al. [35] which showed that the application of cow manure had a good effect on the weight of grain per clump. The highest grain weight was found in the treatment of cow manure at 30 tons/ha, namely 42.71 g and the lowest weight in the control treatment producing 32.08 g.

The interaction of NPK and cow manure had no significant effect on the variable weight of grain per clump. However, the best treatment was shown in the A_2B_3 treatment producing 15.86 g and the lowest result with value of 4.63 g was found at the A_1B_1treatment (Fig. 5).

3.4.6 Percentage of Pithy Grain Weight

The application of NPK resulted in the highest percentage of rice grain weight being found in the recommended dose of NPK treatment (A_1) with value of 84.03% while the lowest percentage of pithy grain was found in the location-specific dose of NPK application (A_2) with value of 83.37% (Table 8). The percentage of pithy grain is influenced by the results of photosynthesis which really need N, P, and K nutrients. Harjadi [30] explained that the results of the photosynthesis process in the form of photosynthesis will be utilized by plants in physiological and metabolic processes. This is useful for filling seeds which can ultimately increase the percentage of pithy grain.

The application of cow manure that produced the highest percentage of pithy grain was found in the application of cow manure at 10 tons/ha (B_3) with value of 88.12% while the lowest percentage of pithy grain was found in the treatment of cow manure at 5 tons/ha (B_1) with value of 78.92% (Table 8). This study provides results that are in line with the research of Azalika et al. [14] where cow manure can increase the percentage of pithy grain. The application of cow manure at 20 tons/ha resulted in a 97.26% higher percentage of full grain compared to that without cow manure. This is because the application of cow manure can meet the needs of plant nutrients when entering the generative phase.

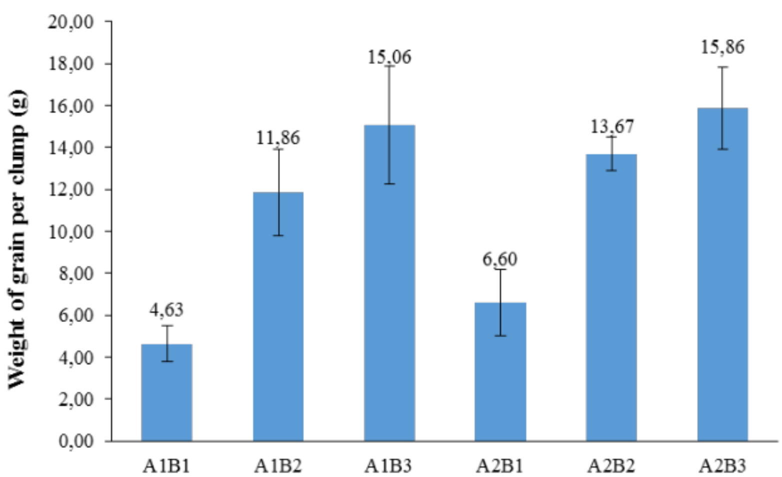

Fig. 5 Interaction effect of NPK and CM on the weight of grain per clump.

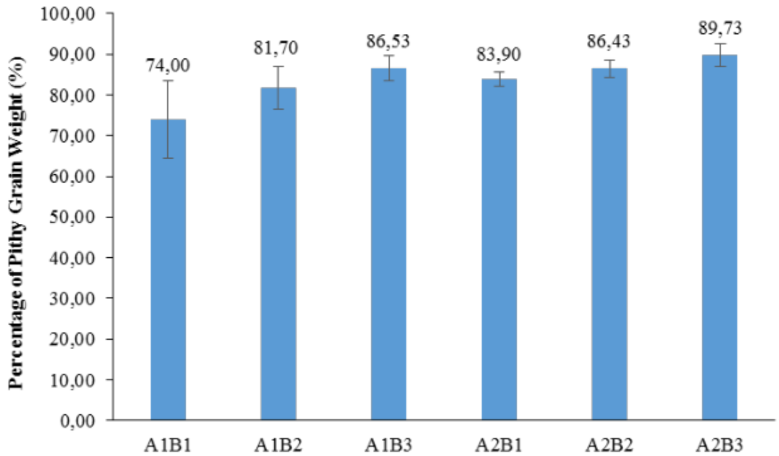

Fig. 6 Interaction effect of NPK and CM on the percentage of pithy grain weight.

The interaction of NPK and cow manure had no significant effect on the variable weight percentage of pithy grain. However, the best treatment was shown in A_2B_3 treatment with value of 89.73% and the lowest at 74% was obtained at A_1B_1 treatment (Fig. 6).

3.4.7 Grain Production

The application of NPK resulted in the highest grain production per ha at the application of site-specific NPK fertilizer (A_2) with value of 1.61 tons/ha while the lowest grain production per ha was found in the application of recommended dose of NPK fertilizer (A_1) producing 1.46 tons/ha (Table 8). The results of this study are in line with the statement of Pattanayak et al. [36] that application of nutrients based on soil tests or nutrient status in the soil in accordance with the concept of site-specific nutrient fertilization can increase the efficiency of nutrient utilization and gain farm profits.

The application of manure resulted in the highest grain production per ha in the application of cow manure at a dose of 10 tons/ha (B_3) at 2.18 tons/ha, while the lowest grain production per ha was found in the application of cow manure at a dose of 5 tons/ha (B_1) of 0.70 tons/ha (Table 8). Cow manure provides nutrients relatively slowly so that in the generative phase, nutrients tend to be available. This causes plants to grow and develop well and can produce higher grain production [37]. This statement is also in accordance with the research results of Ginting et al. [38] that the application of cow manure can increase the maximum number of tillers, the number of productive tillers and the number of grain per panicle and grain production per plot.

The interaction of offering NPK fertilizer and cow manure had no significant effect on grain production per ha. However, the highest treatment was shown in the A_2B_3 treatment of 2.20 tons/ha and the lowest treatment in the A_1B_1 treatment of 0.61 tons/ha (Fig. 7). The best treatment for paddy production per hectare was not found because the minimum grain production per hectare was not achieved. Inpara 8 rice varieties have an average production of 4.70 tons/ha, while in this variable the highest average grain production per ha is only 2.20 tons/ha. This is presumably due to the very acidic soil pH so that plant growth is not optimal. According to Prasetya [39] very acidic soil is caused by the low content of Ca and Mg, resulting in a decrease in pH. In addition, the use of Inpara 8 paddy varieties which are susceptible to brown plant hopper pests can be a factor that causes low rice production. This study showed that some of each treatment did not achieve potential yield production with a value of 6 tons/ha,

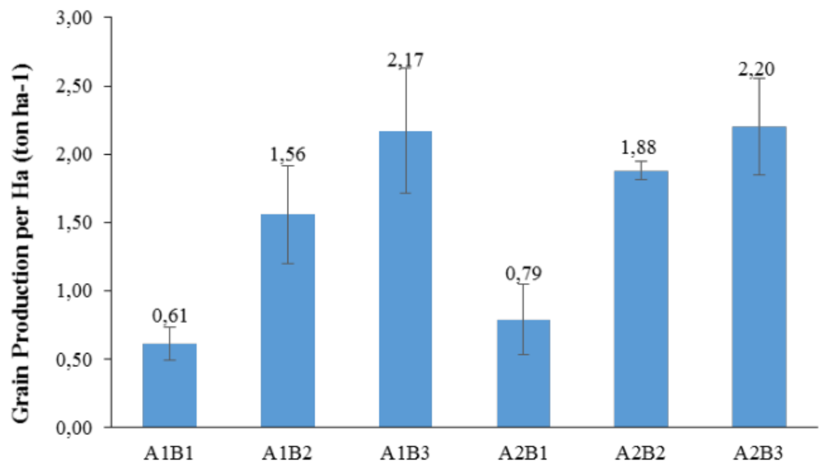

Fig. 7 Interaction effect of NPK and cow manure on rice production.

it is due to the low fertility of the tidal soil. It is also assumed that the non-fulfillment of the number of nutrients N, P, K needed by plants is a factor in not reaching the potential yields in the INPARA 8 rice plant as described, and plant productivity will be hampered and conversely [5]. Budianta et al. [5] reported that application of recommended NPK combined with CM at 10 tons/ha producing grain with value of 2.5 tons/ha.

5. Conclusion

Based on the results of this study it can be concluded that treatment of NPK fertilizer on growth and the best yield of Inpara 8 were obtained from site-specific treatment with a dose of urea 37 kg/ha, SP-36 56 kg/ha, KCl 183 kg/ha. The application of cow manure to the best growth and yield of rice was obtained from the treatment of cow manure at 10 tons/ha. The interaction of site-specific NPK fertilizer treatment at a dose of urea 37 kg/ha, SP-36 56 kg/ha, KCl 183 kg/ha and cow manure at a dose of 10 tons/ha resulted in rice production of 2.20 tons/ha.

References

[1] Naim, M. 2019. "Pertumbuhan dan Produksi Padi Pada Beberapa Varietas Padi Melalui Sistem Tanam Legowo dan Tandur Jajar."*Jurnal Perbal* 7 (1): 19-30. (in Indonesian)

[2] Statistik, B. P. 2020. *Data hasil produksi padi*. BPS Nasional. (in Indonesian)

[3] Haryono. 2013. *Lahan Rawa: Lumbung Pangan Masa Depan Indonesia* Jakarta:IAARD Press. (in Indonesian)

[4] Prasetyo, B. H., Suping, S., Subagyo, H., Mujiono, and Suhardjo, H. 2001. "Characteristics of Rice Soils from the Tidal Flat Areas of Musi Banyuasin, South Sumatra." *Indonesian Journal of Agricultural Science* 2 (1): 10-26.

[5] Budianta, D., Bessy, J. A. L. P., and Hermawan, A. 2021. "Growth and Yield of Rice Planted in a Tidal Soil under NPK in Situ and Cow Manure Application." *J. Trop Soils* 26 (2): 51-62. doi: 10.5400/jts.2021.v26i2.51.

[6] Mawardi, Sunarminto, B. H., Purwanto, B. H., Sudira, P., and Gunawan. 2020. "The Influence of Tidal on Fe Distribution at Tidal Swamp Rice-Farming in Barito River Area, South Kalimantan, Indonesia." *BIO Web of Conferences* 20: 1-6.

[7] Budianta, D., Napoleon, A., Paripurna, A., and Ermatita. 2019. "Growth and Production of Soybean (*Glycine max*(L.) Merill) with Different Fertilizer Strategies in Tidal Soil from South Sumatra, Indonesia." *Spanish J. Soil Sci*. 9: 54-62.

[8] Pertanian, B. L. 2016. "Pemberian Kapur pada Kedelai di Lahan PasangSurut." Access on March9, 2020.http://www.litbang.pertanian.go.id/berita/one/2554/. (in Indonesian)

[9] Ambarita, Y., Hariyono, D., and Aini, N. 2018. "Aplikasi Pupuk NPK dan UreaPada Padi (*Oryza sativa* L.) Sistem Ratun." *Jurnal Produksi Tanaman* 5 (7): 1228-34. (in Indonesian)

[10] Bustami, Sufardi, and Bakhtiar. 2012. "Serapan Hara Dan

Efisiensi Pemupukan Phosfat Serta Pertumbuhan Padi Varietas Lokal." *Jurnal Manajemen Sumberdaya Lahan* 1 (2):159-70. (in Indonesian)

[11] Nagaraja, G. S., Muthappa Rai, B. G., and Guruprasad, T. R. 2008. "Effect of Finter Mittent Mist and Growth Regulator on Propagation of Jasminumgr and if Lorum by Different Types of Cuttings." *Haryana J. Hort. Sci* 20 (3-4): 183-8. (in Indonesian)

[12] Budianta, D., Feabriana, E., and Fitri, S. N. A. 2022. "Application of Cow Manure Combined with Rice Husk Ash to Increase Soybean (*Glycine max* (L.) Merr) Production in Indonesia Ultisol." *Journal of Environmental Science and Engineering B* 11:49-59. doi:10.17265/2162-5263/2022.02.004.

[13] Saragih, S. 2013. *Empat Kunci Sukses Pengelolaan LahanRawa Pasang Surut untuk Usaha Pertanian Berkelanjutan*. Kalimantan Selatan: Balai Penelitian Pertanian Lahan Rawa (BALITTRA). (in Indonesian)

[14] Azalika, R. P., Sumardi, and Sukisno. 2018. "Pertumbuhan dan Hasil Padi SirantauPada Pemberian Beberapa Macam Dan Dosis Pupuk Kandang." *JurnalIlmu-Ilmu Pertanian Indonesia* 20 (1): 26-32. (in Indonesian)

[15] Hatta, M., and Sulakhudin. 2016. "Site Specific Fertilization for Lowland Rice Production in West Kalimantan." *Journal of Soil Science and Agroclimatology* 13 (1): 1-8.

[16] Doberman, A., and Fairhurst, T. 2002. "Rice Straw Management." *Better Crops International* 16: 7-11.

[17] Soil Research Institute. 2002. *Research on Environmental Impact Inventory and Control*. Final report, Research and Development Project Section on Soil Fertility and Climate.

[18] Kaya, E. 2014. "Pengaruh Pupuk Organik dan Pupuk NPK terhadap pH dan KTersedia Tanah Serta Serapan K Pertumbuhan dan Padi Sawah." *J. Buana Sains* 14 (2): 113-22. (in Indonesian)

[19] Damanik, M. M. B., Hasibuan, B. E., Fauzi, Sarifuddin, and Hanum, H. 2010. *Kesuburan Tanah dan Pemupukan*. Medan: Universitas Sumatera Utara. (in Indonesian)

[20] Kuncoro, H. 2008. "Efisiensi Serapan P dan K Serta Hasil Tanaman Padi (*Oryzasativa* L.) pada berbagai Imbangan Pupuk Kandang Puyuh dan pupuk Anorganik di Lahan Sawah Palur Sukoharjo. Skripsi." Universitas Sebelas Maret, Surakarta. (in Indonesian)

[21] Fikdalillah, Basir, M., and Wahyudi, I. 2016. "Pengaruh Pemberian Pupuk Kandang Sapi Terhadap Serapan Fosfor Dan Hasil Tanaman Sawi Putih (*Brassicapekinensis*) Pada Entisols Sidera." *Agrotekbis* 4 (5): 491-9. (in Indonesian)

[22] Bugis, C. C. 2011. "Efek Pemberian Kompos Terhadap beberapa Sifat Kimia TanahUltisol, Pertumbuhan Dan Produksi Tanaman Kacang Tanah (*Arachishipogaea* L.)." Skripsi Fakultas Pertanian Universitas Pattimura, Ambon. (in Indonesian)

[23] Bachtiar, T., Robifahmi, N., Flatian, A. N., Slamet, S., and Citraresmini, A. 2020. "Pengaruh dan Konstribusi Pupuk Kandang Terhadap N Total, Serapan N, dan Hasil Padi Sawah (*Oryza sativa* L.) Varietas Mira-1." *Jurnal Sains danTeknologi Nuklir Indonesia* 21 (1): 35-48. (in Indonesian)

[24] Jeksen, J. 2014. "Pengaruh Dosis Pupuk Kandang Sapi Terhadap Pertumbuhan danHasil Serta Sifat Fisik dan Kimia Tanah Pada Tanaman Kacang Tanah (*Arachis hypogaea* L.)." *Jurnal Agrica* 7 (1): 1-11. (in Indonesian)

[25] Rostaman, T., Angria, L., and Kasno, A. 2003. Ketersediaan Hara P dan K Pada Lahan Sawah Dengan Penambahan Bahan Organik Pada Inceptisols. Prosiding Seminar dan Kongres Nasional Himpunan Ilmu Tanah Indonesia (HITI) X. Buku 1: 116-124. Jurusan Ilmu tanah Fakultas Pertanian UNS Bekerjasama dengan Himpunan Ilmu Tanah Indonesia (HITI). (in Indonesian)

[26] Fageria, N. K., Moreira, A., Ferreira, E. P. B., and Knupp, A. M. 2013. "Potassium-Use Efficiency in Upland Rice Genotypes." *Commun Soil Sci. Plant Anal.* 44: 2656-65. https://doi.org/10.1080/00103624.2013.813031.

[27] Iswahyudi, Saputra, I., and Irwandi. 2018. "Pengaruh Pemberian Pupuk NPK dan Biochar terhadap Pertumbuhan dan Hasil Padi Sawah (*Oryza sativa* L.)." *Jurnal Agrosamudra*. 5 (1): 14-23. (in Indonesian)

[28] Tufaila, M., Yusrina, and Alam, S. 2014. "Pengaruh Pupuk Bokashi Kotoran SapiTerhadap Pertumbuhan dan Produksi Padi Sawah Pada Ultisol Puosu JayaKecamata Konda, Konawe Selatan." *Jurnal Agroteknos*. 4 (1): 18-25. (in Indonesian)

[29] Aksani, D., Budianta, D., and Hermawan, A. 2018. "Determination of Site-Specific NPK Fertilizer Rates for Rice Grown on Tidal Lowland." *Journal of Tropical Soils* 23 (1):19-25. doi: 10.5400/jts.2017.v23i1.19-25.

[30] Harjadi, M. S. 2015. P*engantar Agronomi*. Gramedia Jakarta: PT. (in Indonesian)

[31] Siti, Z. 2011. "Aplikasi Pupuk Bokhasi dan NPK Organik pada Tanah Ultisoluntuk Tanaman Padi Sawah dengan Sistem SRI (System of RiceIntensification)." *Jurnal Ilmu Lingkungan*. 5 (2):114-29. (in Indonesian)

[32] Matshusima, and Muratha. 1980. *Fisiologi dan Moroflogi Tanaman Padi (buku 1)*. Bogor, Indonesia: Balitan Pangan. (in Indonesian)

[33] Rahmiati, and Mawaddah. 2020. "Pengaruh Pupuk Kandang Sapi dan Kombinasi Pupuk Anorganik terhadap Pertumbuhan dan Produksi Tanaman Padi (*Oryza sativa* L.)." *Jurnal Sains dan Aplikasi*. 8 (2): 71-8. (in Indonesian)

[34] Pradipta, A. P., Yunus, A., and Samanhudi. 2017. "Hasil Padi Hibrida GenotipeT1683 Pada Berbagai Dosis Pupuk NPK." *Jurnal Argotech Resh*. 1 (2): 24-8. (in Indonesian)

[35] Sudianto, E., Ezward, C., and Mashadi. 2018. "Pengaruh Pemberian Dolomit danPupuk Kotoran Sapi Terhadap Pertumbuhan dan Produksi Padi Sawah (*Oryza sativa* L.) Menggunakan Tanah Sawah Bukaan Baru." *Jurnal Sains Agro*. 3 (1): 1-16. (in Indonesian)

[36] Pattanayak, S. K., Mukhi, S. K., and Majumdar, K. 2008. "Phosphate Fertilizer Management of Hybrid Rice." *Better Crop-India* 13: 29-31.

[37] Adi, I. G., and Puja, I. N. 2019. "Peningkatan Produktivitas Tanaman Padi SawahMelalui Pemupukan Kompos dan NPK." *Jurnal Agrotrop*. 9 (2): 178-87. (in Indonesian)

[38] Ginting, J., Damanik, B. S. J., Sitanggang, J. M., and Muluk, C. 2015. "Effect of Shade, Organic Materials and Varieties on Growth and Production of Upland Rice." *International Journal of Scientific and Technology Research* 4 (1): 68-74.

[39] Prasetya, M. A. 2014. "Pengaruh Pupuk NPK Mutiara dan Pupuk Kandang Sapiterhadap Pertumbuhan dan Hasil Tanaman Cabai Merah Keriting Varietas Arimbi (*Capsicum annuum* L.)." *Jurnal Agrifor*. 13 (2): 191-8. (in Indonesian)

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