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APPLICATION OF NPK 15-10-12 FERTILIZER TO INCREASE THE YIELD OF PADDY FIELD, FERTILIZATION EFFICIENCY, AND EFFECTIVITY OF FERTILIZING IN INCEPTISOL

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ABSTRACT

The quality and effective fertilizers support site-specific nutrient management of paddy fields, which can increase yields and efficiency of fertilizer. Fertilizer formulas should be based on soil nutrient status and crop requirements. This study aims to examine the reformulation of compound NPK fertilizers for lowland rice. The study was conducted in Cibungbulang, Bogor Regency from October 2020 - March 2021. The experimental design was carried out using a randomized complete block design with 10 treatments, and 3 replications. The treatments consisted of five levels of NPK 15-10-12 fertilizer doses, plus control treatment, NPK 15-15-15 and single NPK as standard, and additional treatment with the addition of straw compost. The plots were made measuring 5 m x 5 m. The results showed that statistically, the application of NPK 15-10-12 fertilizer gave the same effect on plant height, the number of tillers, weight of dry grain harvested, the weight of dry milled grain, and weight of dry straw compared to single NPK fertilizer and NPK 15-15-15. The optimum dose of NPK 15-10-12 fertilizer for lowland rice is 220 kg ha^{-1} combined with Urea at a dose of 225 kg ha^{-1}. At the same dose (300 kg ha^{-1}) the efficiency of NPK 15-10-12 fertilizer (9.70 kg grain kg^{-1} fertilizer) was higher than NPK 15-15-15 fertilizer (8.47 kg grain kg^{-1} fertilizer). Higher efficiency is indicated by lower fertilization doses. The RAE value of NPK 15-10-12 (142%) was higher than that of NPK 15-15-15 at the same dose and single NPK. This research implies that the formula for compound NPK 15-10-12 fertilizer can be used as a substitute for compound NPK 15-15-15 fertilizer.

Keywords: Reformulation, NPK Compound, Rice fields, Yield, Efficiency, Effectivity

INTRODUCTION

New high-yielding varieties of short-lived plants are responsive to macronutrient fertilization, especially N, P, and K. That varieties have been used and have succeeded in increasing the production of rice. However, the use of fertilizer is generally not following the principle of balanced fertilization, which is fertilization based on soil nutrient status and plant needs. The amount of fertilizer used by farmers is often irrational or excessive, especially in intensified paddy fields in rice production centres. Fertilizer use at the farmer level in Banyudono, Boyolali in 2013 averaged 258-276 kg N ha^{-1} (573-613 kg Urea ha^{-1}), 46-69 kg P_2O_5 ha^{-1} (128-192 kg SP-36 ha^{-1}), and 26-54 K_2O ha^{-1} (43-90 kg KCl ha^{-1}) (Samijan *et al*., 2017). As a result of the use of these high doses of fertilizer, intensive paddy fields in rice production centres in Indonesia are dominated by paddy fields with medium to high P and K nutrient status. For this reason, it is necessary to take efficiency measures so that the use of fertilizers becomes effective and efficient.

The application of site-specific fertilization using NPK compound fertilizer is one of the policies of the Ministry of Agriculture in implementing balanced fertilization and increasing the effectiveness and efficiency of fertilizer use. However, the compound fertilizer formula must also be based on the nutrient status of the soil (soil fertility rate) and the plant's need for nutrients as well as the level of plant productivity. The use of compound fertilizer must also still be supplemented with Urea fertilizer as a source of N nutrients which are still lacking.

Fertilization efficiency not only plays an important role in increasing farmers' production and income but is also related to the sustainability of the production system, environmental sustainability, and saving energy resources. Based on the nutrient status map of paddy fields in 23 provinces in 2017 (BBSDLP, 2017; Kasno, 2017), paddy fields in Indonesia covering an area of 7.54 million ha are dominated by medium to high P and K nutrient status, respectively, for P nutrients around 79% and K nutrients around 83% of the rice field area of around 6.87 million ha, which is 92%. Thus, the paddy fields in Indonesia have been saturated with nutrient of P and K.

NPK compound fertilizer subsidized by the Government before 2020 is NPK 15-15-15. Among the three compound NPK fertilizers (NPK 15-15-15, 20-10-10, and 30-6-8) NPK 15-15-15 fertilizers have the highest Relative Agronomic Effectiveness (RAE) values (Kasno *et al.*, 2019). Based on an evaluation conducted in 2011 (Soil Research Centre, 2012), the use of NPK 15-15-15 is not suitable for paddy fields in Indonesia which have diverse fertility rates with P and K nutrient status from low to high. NPK fertilizer 15-15-15 at a dose of 300 kg ha^{-1} when applied to rice fields with moderate to high P and K nutrient status will occur excess P and K nutrients, except for low K nutrient status. Excess nutrients P and K will accumulate in the soil which can cause the soil to become saturated and a waste. Excessive P and K nutrients also lead to a nutrient imbalance in the soil. The provision of high P nutrients on soils in Pakistan is manifestly based on Zn uptake and causes soil Zn deficiency (Rehim *et al*., 2014; Hye *et al*., 2019). The saturation of K and Mg decreases further with the increase in the saturation of Ca in the soil

(Kasno *et al*., 2021). The source raw materials of P and K which are natural mineral materials to produce compound fertilizers are imported. Indonesia does not have these raw material reserves; therefore, it is necessary to reformulate the NPK 15-15-15 compound fertilizer to increase efficiency both in terms of fertilizer production and its use.

The reformulation of compound fertilizer NPK 15-15-15 by reducing P and K levels is expected to (1) increase the effectiveness and efficiency of fertilizer use, and (2) as an integral part of improving the improvement of the Minister of Agriculture Regulation N0. 40/2007 on N, P, and K Fertilization Recommendations on site-specific paddy rice that was updated in 2017, (3) the first step towards the implementation of precision farming, and (4) the savings in the use of nutrients to reduce the fertilizer subsidy budget.

NPK compound fertilizer in the future is an NPK compound fertilizer that can be applied to all conditions of the nutrient status of paddy soils, especially P and K nutrients. The formula has a composition of N, P, and K levels that are close to soil conditions and plant needs and can minimize the advantages and disadvantages of one or two P and K nutrients.

The aims this research to study the effect of applying compound fertilizer NPK 15-10-12 on the growth and yield of paddy rice, as well as to determine the optimum dose, effectiveness, and efficiency of fertilizer use.

MATERIAL AND METHOD

Research Site and Time

The research has been carried out on paddy fields owned by farmers in Cibungbulang District, Bogor Regency, West Java Province (06^o 33' 51'' LS, 106^o 39' 07'' BT), with a place height of 216 m above sea level. The surrounding paddy fields are mostly planted with rice twice, some of which are planted with crops such as corn and vegetable crops. Rice productivity is more than 6 t/ha. The implementation of the activity starts from mid-October 2020 to March 2021.

The materials used in the implementation of the study include compound fertilizer NPK 15-10-12, NPK 15-15-15, Urea, SP-36, and KCl, rice seeds of Inpari 32 variety, and paddy fields owned by farmers with high P and low K nutrient status. Field research supporting materials consist of pesticides and other materials for pest and disease control as well as other supporting materials such as mines and raffia ropes, bamboo, sack sacks, plastic bags, and other supporting materials.

The nutrient content and nutrient amount of N + P_2O_5 + K_2O in NPK 15-10-12 fertilizers qualify as solid compound NPK fertilizers (Table 1). The levels of N, P_2O_5, and K_2O are > 6% each, and the total of the three nutrients is >30%. The moisture content of the fertilizer is 1.7% or below the maximum limit of moisture content allowed in solid NPK fertilizers. The content of heavy metal contamination and Arsenic is also below the permissible limit. Based on the prerequisites for the quality of solid NPK fertilizer in SNI 2803:2012 NPK fertilizer 15-10-12 meets the requirements of a solid NPK fertilizer.

Implementation Procedure

Determination of effectiveness test locations

The location search was carried out by collecting information through field surveys in several rice field locations in West Java

Table 1 Result test of NPK 15-10-12 fertilizer

No.	Parameters	unit	Value	Quality requirements SNI 2803:2012
1.	Total N	%	15.5	Min. 6
2.	Phosphor as P_2O_5	%	10.5	Min. 6
3.	Potassium as K_2O	%	12.5	Min. 6
4.	Total N, P_2O_5, K_2O	%		Min. 30
5.	Water content (w/w)	%	1.70	Max. 3
6.	Heavy metals			
	- Mercury (Hg)	mg kg^{-1}	0.70	Max. 10
	- Cadmium (Cd)	mg kg^{-1}	7	Max. 100
	- Lead (Pb)	mg kg^{-1}	86	Max. 500
7.	Arsenic (As)	mg kg^{-1}	1	Max. 100

related to the availability of irrigation water, land use and fertilization carried out previously, the presence or absence of endemic pests and diseases, far from pollution from both factories and highways, and on large expanses of rice fields, and sufficiently used for research.

Treatment

The experiment was carried out on paddy fields that had medium/high P and K nutrient status. The treatment was tested as shown in Table 2. Fertilizers of single N, P, and K nutrient sources are given in the form of Urea, SP-36, and KCl based on the results of the analysis using the Rice Field Soil Test Device (PUTS). The dose of Urea fertilizer is determined based on rice yields at the experimental site where information from farmers who own rice yields > 6 t ha^{-1} so that the dose used is 300 kg of Urea ha^{-1}. NPK 15-15-15 fertilizer is a fertilizer that has been circulating in the market and used as a comparison. The application of compound NPK fertilizer is more aimed at meeting the needs of P and K nutrients, and N nutrients need to be increased to achieve a dose of urea of 300 kg ha^{-1} or 135 kg N ha^{-1}. Most paddy fields have low C-organic content (<2%) (Kasno *et al.*, 2003, Wibowo and Kasno, 2021), so the addition of straw compost is expected to increase the effectiveness and efficiency of NPK fertilizer use.

Table 2 Treatments of NPK 15-10-12 fertilizer

Treatments	Dosage (kg ha^{-1})			
	NPK	Urea	SP-36	KCl
Control (without fertilizer)	0	0	0	0
Standard (single fertilizer)	0	300	75	50
NPK 15-15-15 300	300	200	0	0
NPK 15-10-12 0	0	300	0	0
NPK 15-10-12 100	100	270	0	0
NPK 15-10-12 200	200	235	0	0
NPK 15-10-12 300	300	200	0	0
NPK 15-10-12 400	400	170	0	0
NPK 15-10-12 225 (75%)	225	225	0	0
NPK 15-10-12 300 (+ straw compost)	300	200	0	0

Experimental Design

The study was conducted using a Randomized Complete Block Design with 10 treatments and 3 replications. The plot size of each treatment is 5m x 5m. Thus, the effectiveness test requires a land of about 1000-15000 m^2 for 3 replications including for ripening and waterways as well as peripheral plants as borders. The waterways are arranged to separate between the intake and removal channels, or so that contamination between treatments does not occur.

Planting and Maintenance

The rice planted is the Inpari 32 variety which is labelled blue, the rice variety used is adapted to the varieties commonly used by local farmers. Rice seedlings aged 21 days after sowing were planted with a 20 cm x 20 cm tile system, 3-5 seedlings per clump. Soil preparation, planting, and weeding are carried out according to local farmer habits. Plants are protected from pests and diseases. In the event of pest and disease attacks, preventive measures are taken as soon as possible by spraying insecticides or fungicides with the principle of maintaining environmental ecology.

Fertilization

NPK compound fertilizer is given entirely when the rice plants are 1 MST (a week after transplanting). Additional Urea fertilizer was given 2 times each half dose at the age of 3 and 5 MST (during the primordia phase). The application of SP-36 and KCl fertilizers was carried out at the same time as the NPK fertilizer application. Before fertilizer is applied, the water in the plot is reduced, and the inlet and outlet waterways are closed. Fertilizer is given by spreading evenly over the entire surface of the plot.

Observation

Observations were made on the agronomic and soil aspects as follows:

Agronomist Aspects

a. The observations of plant growth were carried out on plant height and number of rice tillers at the age of 30, 60, and 90 days after planting. The sample plants observed were 10 clumps of plants per treatment which were determined randomly and marked with stakes. Plant height was measured from the base of the stem or soil surface to the highest part of the plant in each clump. The number of tillers was observed by counting all rice plants in one clump.
b. The observations at harvest were carried out on the weight of dry grain harvested and milled, the weight of wet straw and dry weight. The weight of grain and straw was observed on tiles measuring 2.5 m x 2.5 m in each treatment. Yields are converted to tonnes per hectare.
c. Relative Agronomic Effectiveness (RAE) value of fertilizers tested for effectiveness against comparative fertilizers. RAE is a comparison between the increase in yield caused using fertilizer and the increase in yield of the comparative fertilizer (standard) multiplied by 100% (Machay *et al*., 1984; Chien, 1996):

$$RAE = \frac{A - C}{B - C} \times 100\%$$

Information:

A: Grain yield obtained from the use of tested fertilizers

B: Grain yield obtained from the use of standard fertilizers

C: Grain yield obtained without the use of fertilizers (control)

d. Fertilizer Efficiency

Fertilizer efficiency is the result of the division between grain weight (kg ha^{-1}) in NPK-fertilized treatment minus the yield in the control treatment divided by the amount of fertilizer used (kg ha^{-1}) (Tambunan *et al*., 2014, Ginting *et al*., 2018)

Soil Sampling

Soil sampling at the research site was carried out before the experiment was carried out tillage. Soil samples were taken compositely using a soil drill consisting of 10 sub samples taken at random from the three replicates. Ten sub-samples of soil that have been taken are put into a bucket, stirred until homogeneous, taken about 1 kg, and labelled containing the location and name of the experiment. Soil samples were immediately air-dried, pulverized, sieved with a 2 mm diameter sieve, and analysed in the soil laboratory of the Soil Research Institute, Bogor. Parameters analysed included soil texture, pH, total N content, C-organic content, total P and K content (25% extracted HCl), available P content (Bray 1), and exchangeable base (1N NH4OAc extract, pH 7 ,0), CEC, and base saturation.

Data processing

To determine the effect of treatment, ANOVA analysis was carried out on observational data on rice growth and yield from tiles converted to hectares and continued with DMRT test with a significant level of 5%.

RESULT AND DISCUSSION

Soil Condition

The soil used to experiment the effectiveness of NPK 15-10-12 fertilizer had a silty clay texture and was slightly acidic (pH 5.4) (Table 3). The pH of the water-soluble soil (pH-H_2O) is higher than the pH-KCl, this means that the soil used is predominantly negatively charged.

Table 3 Soil Analysis at Site Research

Parameters	Method	Unit	Value
Texture	Pipette		Silty clay
Sand		%	9
Silt		%	47
Clay		%	44
pH (1:5)			
H_2O	1:5 H_2O		5.4
KCl	1:5 KCl 1N		4.2
Organic Compound			
C	Walkey dan Black	%	1.49
N	Kjeldhal	%	0.11
C/N			14
P_2O_5	Bray-1	Mg kg^{-1}	8.9
P_2O_5	HCl 25%	mg 100 g^{-1}	89
K_2O	HCl 25%	mg 100 g^{-1}	4
Nilai Tukar Kation	(NH_4-Asetat 1N, pH7)		
Ca		$cmol_{(+)}$ kg^{-1}	8.64
Mg		$cmol_{(+)}$ kg^{-1}	0.95
K		$cmol_{(+)}$ kg^{-1}	0.06
Na		$cmol_{(+)}$ kg^{-1}	0.34
Kapasitas Pertukaran Kation	(NH_4-Asetat 1N, pH7)	$cmol_{(+)}$ kg^{-1}	14.72
Kejenuhan basa		%	68

The results of soil analysis showed that the organic C content of paddy fields was low (1.49%), low N and K nutrient content, and high P nutrient extracted with HCl 25% (89 mg P_2O_5 100 g^{-1} soil), and available P extracted by Bray 1 medium, the Ca-dd content is moderate, while the Mg and K-dd nutrients are low. The soil used for the experiment has a low soil CEC, high base saturation. From the description above, it can be stated that the limiting nutrients in the soil include the low content of organic C, N, K, Mg, and CEC in the soil. Based on the content of C-organic, nutrient N, and K the soil used for the experiment is less fertile.

Effect of Fertilization on Rice Growth

NPK fertilization at the age of 30, 60, and 90 days after planting (DAT) significantly increased plant height (Table 4). Plant height on application of NPK 15-10-12 fertilizer was not significantly different compared to single NPK based on soil test and NPK 15-15-15. High doses of NPK 15-10-12 fertilizer did not affect plant height. This is presumably because the dose of N fertilizer given in the form of urea and NPK 15-10-12 at all doses is the same so that it has the same effect. It can be said that the effect of N fertilization is dominant in increasing the height of rice plants.

The results of this study are in accordance with research conducted by Kasno et al., (2016) which stated that N fertilization significantly increased plant height, P and K nutrient fertilization did not increase plant height, except for K fertilization in Jakenan. Meanwhile, the provision of P and K nutrients without N fertilization gave the same results as the control treatment (without fertilization). Other studies have also stated that NPK fertilization, both single and compound NPK, can increase rice yields in irrigated rice fields in Java (Purnomo, 2008, Samira *et al*., 2012; Jumakir, 2018; Kasno *et al*., 2019).

The effect of compound fertilizer NPK 15-10-12 on the number of tillers aged 30, 60, and 90 DAP in Cibungbulang is presented in Table 5. Both single NPK fertilization based on soil tests, as well as NPK 15-15-15 and NPK 15-10-12 were significant. increase the number of tillers. Single NPK

Table 4 The Effect of NPK 15-10-12 fertilizer to Plant Heigh at age 30, 60 and 90 HST in Cibungbulang

Treatments	Plant Heigh (cm), age		
	30 DAP	60 DAP	90 DAP
Control (without fertilizer)	66.47 b	85.17 b	91.26 b**
Standard (single fertilizer)	80.30 a	113.03 a	115.39 a
NPK 15-15-15 300	79.80 a	113.66 a	116.01 a
NPK 15-10-12 0	79.77 a	115.09 a	115.97 a
NPK 15-10-12 100	76.50 a	114.89 a	118.08 a
NPK 15-10-12 200	80.00 a	112.91 a	116.21 a
NPK 15-10-12 300	82.63 a	116.29 a	116.93 a
NPK 15-10-12 400	79.33 a	116.36 a	117.27 a
NPK 15-10-12 225 (75%)	76.37 a	115.46 a	118.28 a
NPK 15-10-12 300 (+ straw compost)	81.53 a	114.23 a	114.58 a

Note ** = numbers in the same column followed by the same letter mean no real difference at a rate of 5% based on the DMRT test, DAP = day after planting fertilization, NPK 15-15-15 and 15-10-12 at a dose of 300 kg ha^{-1} + 200 kg Urea ha^{-1} gave the same number of tillers.

Effect of Fertilization on Plant Yield

Total of Shoots

Samples of rice plants were taken in the filling phase with 10 clumps per plot. The effect of compound fertilizer NPK 15-10-12 on the wet and dry weight of 60 DAP plants in Cibungbulang is presented in Table 6.

Single NPK fertilization, NPK 15-15-15 and 15-10-12 significantly increased wet and dry plant weight. At the same dose of 300 kg ha^{-1}, single N, P, K fertilization increased wet plant weight by 12.54 t ha^{-1}, 10.37 t ha^{-1} on NPK 15-10-12, and 8.79 on NPK 15-15-15 compared to control. However, statistically, the three fertilizer treatments were not significantly different. Likewise, NPK fertilizers, both single and compound, increased plant weight, but the increase was

Table 5 The Effect of NPK 15-10-12 fertilizer to Number of Tiller at age 30, 60 and 90 HST in Cibungbulang

Treatments	Number of Tiller		
	30 DAP	60 DAP	90 DAP
Control (without fertilizer)	11.60 ab	9.87 c	10.67 b**
Standard (single fertilizer)	13.60 abc	12.53 ab	16.67 a
NPK 15-15-15 300	12.60 abc	12.97 ab	16.33 a
NPK 15-10-12 0	13.67 abc	12.47 ab	16.33 a
NPK 15-10-12 100	11.00 c	12.80 ab	16.00 a
NPK 15-10-12 200	14.87 a	12.00 b	16.67 a
NPK 15-10-12 300	14.07 ab	13.13 ab	16.67 a
NPK 15-10-12 400	11.77 bc	13.37 a	17.33 a
NPK 15-10-12 225 (75%)	12.90 abc	13.57 a	17.33 a
NPK 15-10-12 300 (+ straw compost)	12.87 abc	12.53 ab	17.67 a

Note ** = numbers in the same column followed by the same letter mean no real difference at a rate of 5% based on the DMRT test, DAP = day after planting

Table 6 The Effect of NPK 15-10-12 fertilizer to Weight of Shoots at age 30, 60 and 90 HST in Cibungbulang

Treatments	Weight of Shoots (t ha^{-1})	
	Fresh	Dry
Control (without fertilizer)	10.92 d	3.09 b**
Standard (single fertilizer)	23.46 a	5.38 a
NPK 15-15-15 300	19.71 abc	4.62 a
NPK 15-10-12 0	20.67 abc	5.01 a
NPK 15-10-12 100	17.67 bc	4.32 a
NPK 15-10-12 200	21.04 ab	4.95 a
NPK 15-10-12 300	21.29 ab	5.25 a
NPK 15-10-12 400	20.92 ab	4.78 a
NPK 15-10-12 225 (75%)	16.63 c	4.19 a
NPK 15-10-12 300 (+ straw compost)	21.21 ab	4.80 a

Note ** = numbers in the same column followed by the same letter mean no real difference at a rate of 5% based on the DMRT test, DAP = day after planting the same between single NPK fertilizers, NPK 15-15-15, and NPK 15-10-12.

Nutrients N, P, and K are primary macro-nutrients needed by many plants. Nitrogen is a nutrient that plays a role in the process of photosyn-thesis, nitrogen deficiency can cause plant leaves to turn yellow, and plant production to be low. The addition of N nutrients can increase chlorophyll, 1000 grain weight, grain content, and grain yield, the best dose of N fertilization is 168.16 kg ha^{-1} and grain yield 11.80 t ha^{-1} (Peng *et al*., 2021). Phosphorus is a stable nutrient in the soil, at the same dose the addition of P given twice had no effect on grain yields, while P increased grain weight (Archana *et al*., 2018). Most of the paddy fields in Java have moderate to high P and K nutrient status (Kasno, 2017), the application of P fertilizer that is not absorbed by plants in the first season can still be utilized in the second season, a dose of 18 kg P_2O_5 ha^{-1} can increase rice yields by 8, 46% and the addition of higher doses did not increase rice yields (Ismon and Siska, 2018). The application of K fertilizer on rainfed rice fields cannot increase grain yields both at the time of planting by stocking or transplanting (Wihardjaka *et al*., 2022).

Rice Yield

Both single and compound NPK fertilization significantly increased the weight of harvested dry grain, dry milled grain weight, and dry straw weight (Table 7). Fertilization of NPK 15-10-12 had the same effect as single NPK based on soil tests and NPK 15-15-15 on weight of dry grain harvested and weight of milled dry grain. The dose of NPK fertilization 162-120-72 kg ha^{-1} increased the yield of PHB-71 varieties from 4.80 to 7.02 t ha^{-1}, Leader-555 varieties from 5.80 to 8.02 t ha^{-1} compared to the NPK fertilization dose. 108-80-48 kg ha^{-1} (Kamal *et al*., 2016).

The weight of dry straw at the NPK treatment of 15-10-12 0 kg ha^{-1} had an effect that was not significantly different from the control treatment (without NPK fertilizer). This means that applying Urea fertilizer without nutrients P and K increases the unreal weight of dry straw. The dry weight of straw at a dose treatment of 300 kg ha^{-1} gave the same response to NPK 15-10-12, single NPK treatment, and NPK 15-15-15. This shows that NPK 15-10-12 gives the same effectiveness against dry straw weight compared to NPK 15-15-15 and single NPK. The increase in the dose of NPK 15-10-12 from 0 to 200 kg

Table 7 The Effect of NPK 15-10-12 fertilizer to Yield of Grain in Cibungbulang

Treatments	DGWH	DGWM	Dry Straw Weight
	……………. t ha^{-1} …………		
Control (without fertilizer)	3.97 b	3.14 b	5.74 d**
Standard (single fertilizer)	6.03 a	5.81 a	8.72 ab
NPK 15-15-15 300	6.51 a	5.90 a	7.83 abc
NPK 15-10-12 0	5.55 ab	5.20 a	6.75 cd
NPK 15-10-12 100	6.88 a	6.02 a	8.03 abc
NPK 15-10-12 200	6.70 a	6.00 a	8.92 a
NPK 15-10-12 300	6.89 a	5.28 a	6.95 bcd
NPK 15-10-12 400	6.50 a	4.99 a	7.69 abc
NPK 15-10-12 225 (75%)	6.58 a	5.55 a	7.81 abc
NPK 15-10-12 300 (+ straw compost)	6.96 a	5.60 a	7.85 abc

Note ** = numbers in the same column followed by the same letter mean no real difference at a rate of 5% based on the DMRT test, DGWH = dry grain weight of harvest, DGWM = dry grain weight of the mill ha^{-1} was noticeably increased in the weight of dry hay and at a dose of 300 kg ha^{-1} began to decrease. The highest dry straw weight is achieved at NPK doses of 15-10-12 200 kg ha^{-1} plus 235 kg urea ha^{-1}.

Rice straw compost given at the beginning of planting could not increase the weight of harvested dry grain, dry milled grain weight, and dry straw weight. The results of this study are the same as those of Esidorus *et al*., (2017). Plant height, average weight of harvested dry grain, weight of milled dry grain in paddy fields treated with straw compost 2 t ha^{-1} were the same as those without straw compost. Most of the organic C content of paddy fields is very low, with 2 t of straw compost means that it only increases 0.03% of organic C if the BD of paddy soil is 1 g cm$^{3-1}$ and the soil depth is 20 cm, and organic C content of compost straw is 30%. Thus, it is understandable that the application of 2 t ha^{-1} of straw compost has not been able to increase the growth and yield of lowland rice.

Figure 1 shows the relationship between dry grain weight and NPK fertilizer dose 15-10-12. NPK fertilization 15-10-12 was seen to increase the dry grain weight of the harvest, the highest increase occurred at a dose of < 200 kg ha^{-1}. At a dose of > 200 kg ha^{-1} NPK fertilizer 15-10-12 rice yields have begun to decline and at its peak, it was obtained around a dose of 300 kg ha^{-1} and began to decrease to a dose of 400 kg ha^{-1}.

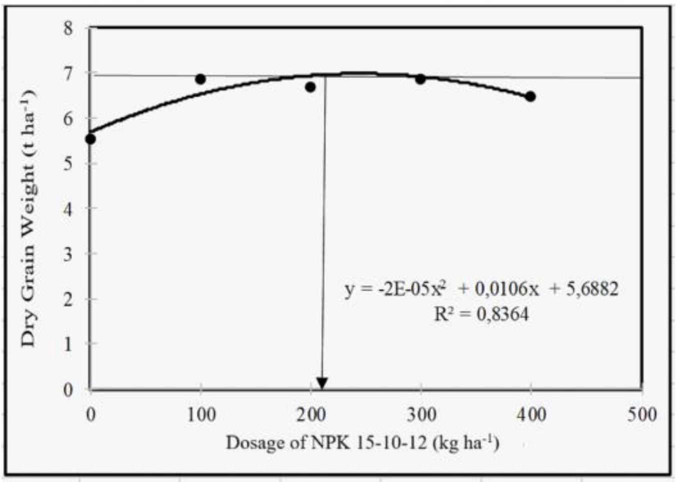

Figure 1 The Effect of NPK 15-10-12 fertilizer to Yield of Grain in Cibungbulang

The graph of the relationship between the dose of NPK fertilizer 15-10-12 with the dry grain weight of the harvest is quadratic with $R^2 = 0.84$. Based on the quadratic concomitant derivatives, it is known that the maximum fertilizer dose is 265 kg ha^{-1}, and the maximum rice yield is achieved at 7.09 t ha^{-1}. Based on the chart (Figure 1), the optimum dose of NPK 15-10-12 fertilizer is about 220 kg ha^{-1} plus Urea fertilizer of 235 kg ha^{-1}.

Efficiency of Fertilizer Use NPK 15-10-12

The efficiency of fertilizer use is calculated from the increase in yield due to fertilizer application (fertilization treatment yield - control) divided by the dose of fertilizer added. The efficiency of using NPK 15-10-12 fertilizer on rice yields in Cibungbulang is presented in Table 8. At the same dose (300 kg ha^{-1}), the efficiency of NPK 15-15-15 is relatively the same as the efficiency of using NPK 15-10-12 fertilizer is the same. The higher efficiency of NPK 15-10-12 fertilization occurred at lower fertilizer doses, namely 100>200>300>400. This means that at a lower dose of fertilizer, one kg of fertilizer can produce more grain. The application of organic straw compost for only one growing season has not been able to increase fertilization efficiency.

Relative Agronomic Effectiveness (RAE)

The RAE value of NPK 15-10-12 fertilizer was calculated based on the weight of dry grain harvested which is presented in Table 9. A single NPK fertilizer based on the soil test was used as a standard in the calculation of RAE. The results of the RAE calculation show that NPK 15-10-12 fertilization is more than 100%, this indicates that NPK 15-10-12 fertilizer is effectively used as NPK fertilizer in rice fields. At a dose of 300 kg NPK + 200 kg Urea ha^{-1}, the RAE value for NPK 15-10-12 was higher than for NPK 15-15-15. This means that NPK 15-10-12 fertilizer is more effective than NPK 15-15-15 and single NPK.

CONCLUSION

The application of both single and compound NPK fertilizers can significantly increase the growth and yield of rice. The optimum dose of NPK 15-10-12 fertilizer for lowland rice is around 220 kg ha^{-1} and urea fertilizer are around 235 kg ha^{-1}. The efficiency of fertilizing NPK 15-10-12 (9.70 kg grain kg^{-1} fertilizer) with the same dose was relatively the same as NPK 15-15-15 (8.47 kg grain kg^{-1} fertilizer). NPK 15-10-12 fertilizer is effectively used as a compound fertilizer for lowland rice with RAE value > 100. The application of straw compost in the first planting season has not been able to increase rice growth and yield.

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Table 8 Efficiency of NPK 15-10-12 Fertilizer to Yield of Grain in Cibungbulang

Treatments	Efficiency of NPK 15-10-12
	…….. kg grain kg^{-1} fertilizer …….
NPK 15-15-15 300	8.47
NPK 15-10-12 100	29.10
NPK 15-10-12 200	13.70
NPK 15-10-12 300	9.70
NPK 15-10-12 400	6.30
NPK 15-10-12 225 (75%)	11.60
NPK 15-10-12 300 (+ straw compc	10.00

Table 9 RAE Value of NPK 15-10-12 Fertilizer to Yield of Grain di Cibungbulang

Treatments	RAE
	…………….. %
Standard (single fertilizer)	100
NPK 15-15-15 300	123
NPK 15-10-12 0	77
NPK 15-10-12 100	141
NPK 15-10-12 200	133
NPK 15-10-12 300	142
NPK 15-10-12 400	123
NPK 15-10-12 225 (75%)	127
NPK 15-10-12 300 (+ straw compost)	145

REFERENCES

Archana K., T.P. Reddy, T. Anjaiah, and B. Padmaja. 2018. *Effect of level of phosphorus and its time of application on soil nutrient status and yield of rice grown on P accumulated soil*. Multilogic in Science. Vol. 8(C): 299-302.

Badan Standardisasi Nasional 2803:2012. 2012. *Pupuk NPK padat*. 21 halaman.

Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian (BBSDLP). 2017. *Peta status hara P dan K tanah sawah di 23 Provinsi di Indonesia*. BBSDLP. Bogor.

Balai Penelitian Tanah. 2012. *Laporan Kajian Evaluasi Penggunaan Pupuk Majemuk Subsidi NPK 15-15-15, NPK 20-10-10, dan NPK 30-6-8 untuk Padi Sawah*. Kerjasama antara Pupuk Sriwidjaja Holding Company dengan Balai Penelitian Tanah, 2011. Bogor.

Chien S. H. 1996. *Evaluation of Gafsa (Tunisia) and Djebel Onk (Algeria) phosphate rocks and soil testing of phosphate rock for direct application*. *In* Nutrient Management for Sustainable Crop Production in Asia, Bali, Indonesia, 9-12 December 1996, p.175-185. Edited by A.E. Johnston and J.K. Syers.

Esfahani M., H.R. Ali Abbasi, B. Rabiei, and M. Kavousi. 2008. *Improvement of nitrogen management in rice paddy fields using chlorophyll meter (SPAD*). Paddy Water Environ (6):181-188.

Esidorus, S. Sagiman, dan Wasi'an. 2017. *Pengaruh pemberian kompos jerami padi dan tinggi genangan air terhadap pertumbuhan dan hasil tanaman padi (Oryza sativa L) pada tanah alluvial*. Agrica Ekstensia, Vol. 11(2):61-66.

Ginting E.N., S. Rahutomo, dan E. S. Sutarta. 2018. *Efisiensi serapan hara beberapa jenis pupuk pada bibit kelapa sawit*. J. Pen. Kelapa Sawit, Vol 26(2):79-90.

Hye M.A., K.M.M. Rahman, P.P. Das, I.M.A. Hossain, and B.P. Ray. 2019. *Contribution of zinc and phosphorus on yield phosphorus and zinc content in aman rice and distribution in post-harvest soil*. Horticul. Int. J. Vol. 3(5):209-212.

Ismon, dan W. Siska. 2018. P*engaruh residu pupuk P pada MT I terhadap status P tanah dan hasil padi sawah pada MT II di Kabupaten Dharmasraya, Sumatera Barat*. Jurnal Pengkajian Pengembangan Teknologi Pertanian. Vol. 21(1):63-72.

Jumakir. 2018. *Pengaruh pemupukan NPK dan pupuk organic terhadap produktivitas padi di lahan sawah irigasi Provinsi Jambi*. J. Agroecotania Vol. 1(2):22-30.

Kamal M.A., F. Rasul, A. Zohaib, K. Ahmad, T. Abbas, T. Rasool, and M. Mawaz. 2016. *Effect of NPK application at various levels on yield and quality of two rice hybrids*. Scientific Journal of Seoul Sciences. Vol. 4(1):14-19.

Kasno A., D. Setyorini, dan Nurjaya. 2003. *Status C-organik lahan sawah di Indonesia*. Kongres HITI VIII Padang, 21-23 Juli 2003. 481-495.

Kasno A. 2017. *Karakteristik tanah sebagai dasar pengelolaan hara lahan sawah untuk tanaman padi*. Pros. Konser Karya Ilmiah Nasional 2017, Menghadapi Tantangan dan Meraih Kemandirian Pertanian Indonesia. UKSW Salatiga, 5 Mei 2017:20-34.

Kasno A., Nurjaya, dan S. Rochayati. 2019. *Efektivitas beberapa formula pupuk majemuk NPK dalam meningkatkan* *produktivitas padi sawah*. Jurnal Tanah dan Iklim. Vol. 43(1):71-81.

Kasno A., T. Rostaman, dan D. Setyorini. 2016. *Peningkatan produkstivitas lahan sawah tadah hujan dengan pemupukan hara N, P, dan K dan penggunaan padi varietas unggul*. Jurnal Tanah dan Iklim. Vol. 40(2):147-157.

Kasno A., D. Setyorini, and L.R. Widowati. 2021. *Cation ratio and its relationship with other soil nutrients of Java intensified lowland rice. 1st International Conference on Sustainable Tropical Land Management*. IOP Conf. Series: Earth and Environmental Science 648 (2021) 012015 IOP Publishing. DOI:10.1088/1755-1315/648/1/012015

Machay A.D., J.K. Syers, and P.E.H. Gregg. 1984. *The ability of chemical extraction procedures to assess the agronomic effectiveness of phosphate rock materials*. New Zealand Journal of Agriculture Research. 27:219-230.

Peng J., Y. Feng, X. Wang, Jie Li, Guiling Xu, S. Phonenasay, Qiangxin Luo, Zhili Han, and Wei Lu. 2021. *Effects of nitrogen application rate on the photosynthetic pigment, leaf fluorescence characteristics, and yield of indica hybrid rice and their interrelations*. Scientifc Reports. (2021) 11:7485.

Peraturan Menteri Pertanian No. 36/ Permentan/SR/10/2017. 2017. *Tentang Pendaftaran Pupuk Anorganik*. Kementerian Pertanian. Jakarta.

Purnomo J. 2008. *Pengaruh pupuk NPK majemuk terhadap hasil padi Varietas Ciherang dan sifat kimia tanah Inceptisol*. Pros. Nasional dan Dialog Sumberdaya Lahan Pertanian. Bogor, 18-20 November 2008:341-352.

Rehim A., M.Zafar-ul-Hye, M. Imran, M.A. Ali, and M. Hussain. 2014. *Phorphorus and Zinc application improves rice productivity*. Pakistan Journal of Science. Vol. 66(2):134-139.

Samijan, T.R. Prastuti, dan Warsito. 2017. *Evaluasi lapang rekomendasi pemupukan padi sawah berdasarkan pemupukan hara spesifik lokasi berbasis internet di Jawa Tengah, Indonesia*. Planta Tropika: Jurnal Agrosains. Vol. 5(1):23-33.

Samira D., Sufardi, Zaitun, Chairumas, A. Gani, P. Slavich, and M. McLeod. 2012. *Effect of NOK fertilizer and biochar residue on paddy growth and yield of second planting. The Proceedings of the 2nd Annual International Conference Syiah Kuala University*. Banda Aceh, 22-24 November 2012:157-161.

Sikuku P.A., J.M. Kimani, J.W. Kamau, and S. Njinju. 2016. *Influence of nitrogen supply on photosynthesis, chlorophyll content and yield of improved rice varieties under upland condition in Western Kenya*. American Journal of Experimental Agriculture. 13(2):1-14.

Standar Nasional Indonesia (SNI). 2012. *Pupuk NPK Padat*. SNI 2803:2012. Badan Standardisasi Nasional (BSN), ICS 65.080. Jakarta.

Susanto A.N., dan M.P. Sirappa. 2007. *Penelitian petak omisi pada kajian system usahatani padi lahan sawah irigasi di Kabupaten Buru*. Pros. Seminar Nasional: Akselerasi Inovasi Teknologi Pertanian Spesifik Lokasi Mendukung Ketahanan Pangan di Wilayah Kepulauan. Hal. 347-357.

Tambunan A.S., Fauzi, dan H. Guchi. 2014. *Efisiensi pemupukan P terhadap pertumbuhan dan produksi tanaman jagung (*Zea mays L.*) pada tanah Andisol dan Ultisol*. Jurnal Online Agroekoteknologi. Vol. 2(2):414-426.

Wibowo H., and A. Kasno. 2021. *Soil organic carbon and total nitrogen dynamics in paddy soils on Java Island, Indonesia*. IOP Conf. Series: Earth and Environmental Science 648 (2021). DOI:10.1088/1755-1315/648/1/012192.

Wihardjaka A., E.S. Hrsanti, and A.N. Ardiwinata. 2022. *Effect of fertilizer management on potassium dynamics and yield of raifed lowland rice in Indonesia*. Chilean Journal of Agricultural Research 82(1):33-43.

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