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Nutrient Balance at Integrated Nutrient Management on Lowland Rice Which is Dominated by 1:1 Clay Mineral for High Potential Rice Yields

Antonius Kasno[1]

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ABSTRACT

Nutrient Balance at Integrated Nutrient Management on Lowland Rice Which is Dominated by 1:1 Clay Mineral for High Potential Rice Yields (A Kasno): The curve of the most recent production period of the intensification lowland rice was stating a levelling off. In the effort to increase the rice production, an improvement on intensification quality using a balance fertilizing concept was determined. The objective of this research was to study the nitrogen, phosphorus and potassium nutrient balance among the integrated nutrient management. The field experiment was conducted in Margodadi and Mulyosari, Metro, Lampung, in dry season 2006. A randomized Complete Block Design was applied with ten treatments and three replications. The treatments combined of inorganic and organic fertilizers. Phosphorus and potassium dosages and proportions were determined based on the previous research held in 2005, it were 100 kg SP-36 ha^{-1} and 80 kg KCl ha^{-1} in Mulyosari, and 130 kg SP-36 ha^{-1} and 120 kg KCl ha^{-1} in Margodadi. At the beginning, 100 kg urea was added. The crop's need of nitrogen was monitored using the Leaf Color Chart every 7-10 days, starting from the 21st days after planting, up to the phase panical inisiation. Total urea fertilizer added was 300 kg ha^{-1}. Organic matters consisting of 5 Mg ha^{-1} rice straw and 2 Mg ha^{-1} cow manure were added. Ammonium sulphate was added to provide 10 kg S ha^{-1} and by 5 minutes dying the seedlings on 0,05% $ZnSO_4$ solution before planting was intended to provide Zn nutrient. Micro nutrient Cu was provided by adding 5 kg ha^{-1} $CuSO_4$. The plot size was 5m x 5m, and Hybride Rice, PHB 71, was used as the plant indicator. Observation was focused on the weight of dry straw and yield and on analysing the nutrient content of straw and grain yield. The result showed that the weight of the yield increased from 7.44 to 7.93 Mg ha^{-1} by adding Cu in Mulyosari. The total production of Hybride PHB 71 in the NPK treatment based on the Margodadi and Mulyosari nutrient status were 7.44 and 7.00 Mg ha^{-1}, respectively. Adding KCl 120 kg ha^{-1} in Margodadi and 80 kg ha^{-1} in Mulyosari was equal to the incorporating 5 Mg ha^{-1} rice straw in acheiving the same rate of the weight of the yield. Incorporating straw 5 Mg ha^{-1} increased the nutrients content of harvested straw/grain: N from 105 to 123 kg ha^{-1}, P from 26 to 34 kg ha^{-1}, and K from 106 to 114 kg ha^{-1} in Margodadi, while in Mulyosari increasing N from 114 to 128 kg ha^{-1}, P from 26 to 34 kg ha^{-1}, and K from 71 to 87 kg ha^{-1}. Nutrient balance in Margodadi was in the range of -12 to 68 kg ha^{-1}, -16 to -7 kg ha^{-1}, and -68 to -5 ka ha^{-1} for N, P, and K, respectively, while in Mulyosari was in the range of -23 to 67 kg ha^{-1}, -19 to -10 kg ha^{-1} and -60 to -28 kg ha^{-1} for N, P, and K, respectively. Incorporating rice straw to the rice field was able to improve the balance of N, P, and K nutrients in the rice field.

Keywords: Nutrient balance, nutrient management, rice yield potential, 1:1 clay mineral

INTRODUCTION

Rice is the staple food and having a strategic value in the national food security. According to Adiningsih (1992) in the 1988-1991 period, the intensive cultivated land for rice was already experiencing symptoms of levelling off productivity. While in the 2000-2005 period, the average of rice production increased 0.47%. The productivity of paddy in 2005 was 4.22 Mg ha^{-1}. The productivity remains low, far below the potential productivity in the year. The low rice productivity was caused by the imbalancy of nutrients additions. Nutrient imbalancy in soil can be caused by the excessive use

[1]Indonesian Center for Agricultural Land Resource Research and Development Agency for Agricultural Research and Development. Present address: Jl. Ir. H. Juanda No. 98, Bogor 16123, Indonesia, email: a_kasno@yahoo.com

of chemical fertilizers. Uncontroled use of inorganic fertilizers can also reduce the productivity and environmental quality (Adiningsih *et al*. 1989; Moersidi *et al*. 1990; Rocstrawati *et al*. 1990; Adiningsih 1992).

Fertilizing based on the soil nutrient status and the crop needs balance nutrient is the key to improve soil productivity and rice production sustainability. Balance fertilizing is an effort to improve /increase the farmer's income and their bargaining position. Balance fertilizing is adding fertilizer into the soil to get an optimum content of soil nutrients and optimum environmental growth, and in return to get an optimum productivity. The results of soil analyses described the soil nutrient status andbased on this it can be decided what kind and how much nutrient to be added. Balance fertilizing is not only based on soil analyses but also based on: (1) soil type and its potential productivity, (2) planting/cropping pattern, and (3) the history of land management (Fairhust 2002). Each soil type represents difference nutrient status and availability. Makarim (2005) said that every ton dry milled grain in Java and Bali wetland required 18.8, 2.4 and 16.2 kg N, P and K, respectively.

C-organic content of most intensive cultivated wet land was in low status (Kasno *et al*. 2003). Incorporating 5 Mg ha^{-1} straw in rice field in Muarabeliti and Tatakarya can increase the content of soil organic, K and CEC and increase the grain yield (Nursyamsi *et al*. 2000). Most of the intensive cultivated wet land rice required N to increase paddy yield. Without adding N, the rice performs worst growth and lowest yield compared to those added by either no P or K. In the rice field dominated by 1:1 clay type and having high, medium, and low status of P nutrient, the proper amount of SP-36 for VUTB was 100, 130 and 160 kg ha^{-1}, respectively; while the proper ammount of KCl was 80 and 160 kg ha^{-1} for rice field with high and low K nutrient status, respectively (Kasno *et al*. 2006).

The highest lowland rice productivity will be realizable in the best nutrient balance condition. There are two concepts in the soil nutrient balance. The first concept is: (1) nutrient balance among nutrients in the soil solution, and (2) nutrient balance between nutrient added and nutrients carried away in harvest time. The second concept of nutrient balance is a number derived from substracting the amount of nutrient in the fertilizer added by the number of nutrients taken out through harvesting (nutrient content in straw and grain yield) (Dierolf and Yost 2000). According to Fairhust (2002) nutrient balance is a gap between the number of nutrients input (fertilizing, organic material, crop residues, irigation water, rain and dust) and the number of nutrient output (nutrient loss, uptaken by plant, evaporation, and loss through leaching, erosion, and surface flow).

To increase the paddy yield a crop genetic improvements are needed. High yield potential variety is one of the the genetic improvements to improve yield. Demonstration plot in Takalar, South Sulawesi, using Fatmawati variety performs yield 31.2% higher than the Ciliwung Variety (6.8 Mg ha^{-1}) (Supriharto *et al*. 2004).

This paper aimed to study the balance of N, P and K nutrients on the integrated nutrient management technology for high yield potential rice variety in the rice field dominated by 1:1 clay mineral type.

MATERIALS AND METHODS

This research was carried out at the intensive cultivated rice field dominated by 1:1 clay mineral in Mulyosari Village, Metro, Lampung (105^{o}17'25" E 5^{o}09'11" S), and Margodadi, Metro, Lampung (105^o 18'57" E 95^{o}08'34"S), in dry season, 2006.

Field experiments used a Randomized Complete Block Design with 10 treatments, and each treatment is replicated 3 times. The treatment consists of a combination of inorganic and organic fertilizers. The ammount of P and K fertilizer were determined based on the research results of Kasno *et al*. (2006). The P and K fertilizers for the high and medium nutrient status were 100 and 130 kg ha^{-1} of SP-36, respectively and 80 and 160 kg ha^{-1} of KCl, respectively. Paddy Soil Tester Kit was used to determine the K nutrient status and to determine the ammount of SP-36 and KCl to be added. a 100 kg ha^{-1} urea fertilizer was added at the beginning and the requirement of N nutrient was monitored using the Leaf Color Chart starting at the 21st day after planting and controlled every 7-10 days. The dosages of fertilizer used in Mulyosari were 100 kg ha^{-1} SP-36 and 80 kg ha^{-1} KCl, while in Margodadi were 130 kg ha^{-1} SP-36 and 120 kg ha^{-1} KCl. The total Urea fertilizer added to the experiment was 300 kg ha^{-1}.

Organic matter was added as fresh rice straw 5 Mg ha^{-1} and cow manure 2 Mg ha^{-1}. ZA fertilizer was added to provide 10 kg S ha^{-1}. According to Widowati *et al*. (1999) Lampung soils required more Mg and Ca. Dolomit was added to provide 20 kg Mg ha^{-1}. Seedlings was dyed into 0.05% $ZnSO_4$ solutions for

5 minutes before transplanting to provide Zn nutrient, and 5 kg ha^{-1} $CuSO_4$ was added to provide Cu micro nutrient. Urea, SP-36, KCl, S, Ca, Mg, and Cu were added at 7 days after planting, by spreading the fertilizers over the land. Straw was incorporated on 2 weeks before planting or at the first tilling. Manure added 1 week before planting, KCl added once more during the primordia. Plot size 5m x 5m, Hybride PHB 71 variety was used as the crop indicator. Rice planted with 20 cm x 20 cm spacing. Observation was focused on the soil laboratory analyses, the weight of dry milled grain, the absorbtion of macro and micro nutrients.

One kg of plant and 1 kg of grain sample were taken randomly at harvest time from each treatments and then oven dried for 48 hours at 70^{o}C. Then, the samples were milled and analysed at laboratorium.

The amount of nutrient carried by dry straw and grain on harvesting time was calculated by multiplying the nutrient content with straw and grain yield weight. The amount of added nutrient was calculated by summing up all added both inorganic and organic fertilizer (Straw and manure incorporation). The nutrient balance was calculated by substracting the amount of addicted nutrients with the ammount of nutrient taken out by the crop (Dierolf and Yost 2000; Fairhust 2002). Nutrient balance achieved when the difference of nutrirnt input and nutrient output was relatively small.

The content of P, Ca, Mg, Na, and Zn in the manure added in Margodadi's experiment was higher than the mentioned nutrients content in straw (Table 1). All nutrient content in manure added in Mulyosari's experiment were higher than those in straw. The differences level of nutrient content between the manure and the straw were due to differences between the feed sources and the soil fertility where the feed and straw taken from.

RESULTS AND DISCUSSION

The soil texture at Margodadi Village was sandy clay loam (Table 2). Having low content of C-organic and N-total, such condition made the fertilizing less effective. The level of P which extracted by HCl 25% and Bray-1 was high. This probably due to the residual effects of the continuously P fertilization, while the characteristic of P in the soil was not labile. The content of K extracted by HCl 25% and NH_4OAc 1N pH 7.0 were low. The content of Ca and Mg were low, and the soil CEC was low. This was probably caused by weathering and fast nutrients leaching in the soil dominated 1:1 clay mineral type. Base saturation status was 48%, this means that the soil contained more acid cations (52%).

The soil texture in Mulyosari was clay loam, soil pH H_2O was 5.0, levels of C-organic and N-total are low. Content of P extracted by HCl 25% and Bray 1 is high, content of K extracted in HCl 25% and NH_4OAc 1 *N* pH 7.0 are low. The critical level of K nutrient (extracted by NH_4OAc 1N pH 7) for rice was 0.2 cmol(+) kg^{-1} soil (Pillai 2005), 60 ppm K (Hill *et al.* 1998). Therefore, K nutrient in the rice fields in Mulyosari was still lower than the critical level for the rice crop. The content of Ca, Mg, Na and CEC on the soil low, and the base saturation was high. Based

Table 1. The results of the analysis of cow manure and rice straw used in nutrient balance experiments in Lampung, the dry season 2006.

Chemical characteristic	Organic matter from Margodadi		Organic matter from Mulyosari	
	Cow manure	Straw	Cow manure	Straw
Water content (%)	6.8	6.3	4.9	6.3
N (kg Mg^{-1})	7.4	11.2	26.1	11.2
P_2O_5 (kg Mg^{-1})	11.2	3.8	8.8	2.3
K_2O (kg Mg^{-1})	17.9	26.2	8.7	26.6
Ca (kg Mg^{-1})	6.8	2.4	7.7	2.7
Mg (kg Mg^{-1})	5.1	2.0	3.4	1.7
Na (kg Mg^{-1})	1.2	0.2	0.6	0.5
Fe (kg Mg^{-1})	4.2	3.3	4.4	1.7
Mn (kg Mg^{-1})	0.117	0.183	0.115	0.092
Cu (kg Mg^{-1})	0.019	0.011	0.026	0.009
Zn (kg Mg^{-1})	0.126	0.049	0.108	0.064

Table 2. Soil analysis result on nutrient balance experiment site in Lampung, dry season 2006.

Soil characteristic	Margodadi	Nutrient status	Mulyosari	Nutrient status
Texture	Sandy clay loam		Clay loam	
pH (H_2O)	5.00	Acid	5.00	Acid
Organic matter				
C-organic (%)	0.85	Low	1.08	Low
N-total (%)	0.08	Low	0.08	Low
C/N	11	Medium	14	Medium
Extract HCl 25 %				
P_2O_5 (mg 100 g^{-1})	58	High	128	High
K_2O (mg 100 g^{-1})	5	Low	6	Low
Bray 1 (mg P_2O_5 kg^{-1})	33.00	High	42.30	High
Extract NH_4OAc 1 N pH 7				
Ca (cmol(+) kg^{-1})	1.66	Low	3.36	Low
Mg (cmol(+) kg^{-1})	0.44	Low	0.77	Low
K (cmol(+) kg^{-1})	0.05	Low	0.10	Low
Na (cmol(+) kg^{-1})	0.08	Low	0.12	Low
CEC (cmol(+) kg^{-1})	4.63	Low	7.10	Low
BS (%)	48	Medium	61	High

on the nutrient saturation, the K nutrient availability is very low.

Based on the level status of C-organic, P, K and Ca nutrients and the base saturation, the experiment sites in Mulyosari was more fertile than those in Margodadi.

Experiment in Margodadi

The weight of dry straw (on the rice straw treatment, without K fertilizer) was likely to be lower than the NPK fertilization (Table 3). Application of manure on N½PK treatment tends to increase the paddy yield compared with NPK fertilization. It means that 2 Mg ha^{-1} manure can provide a half dosage of P fertilizer.

Incorporating rice straw, adding manure, and adding S, Cu and Zn nutrients had no effect to the dry weight of grain. Incorporating 5 Mg ha^{-1} rice straw, without adding KCl fertilizer can equally increase the weight of dry grain as the NPK fertilizer treatment does. It means that incorporating rice straw can provide the K nutrient. Dierolf and Yost (2000) said that the rice straw incorporation can reduce the K fertilizing in rice-soybean cropping. Taking the rice straw out from the rice field continuously without adding K fertilizer, in a long period of time, can lead to K deficiency (Dobermann and Fairhust 2002).

The weight of dry grain in the manure + N½PK treatment made no difference to the NPK treatment (Table 3). This means that adding 2 Mg $ha^{-1}$of manure can reduce a half dose of SP-36 fertilization.

Adding secondary macro and micro nutrient had no effect to plant growth and grain yield in wet land rice. The secondary macro and micro nutrients in the soil were still above the nutrient critical level (Table 2), and the mentioned nutrient need was provided by the available nutrients in the soil.

Output or nutrients absorption was the amount of nutrient content in the straw and grain. In the daily habit in the field, the two production components were taken out from the rice field. The N content taken by with the plants was vary from 105 to 152 kg ha^{-1}, P ranged between 28 and 36 kg ha^{-1} and K ranged between 94 and 128 kg ha^{-1}. According to Pillai (2005), the amount of nutrients taken out by the harvested were 7.6 kg N, 1.1 kg P_2O_5, and 28.4 kg K_2O Mg^{-1} of straw as well as 14.6 kg N, 6.0 kg of P_2O_5, and 3.2 kg K_2O Mg^{-1} of grain.

Adding 5 Mg ha^{-1} of straw without K fertilizer can increase the amount of N nutrient which was transported during harvest. Similar results were showed by the adding of manure + Ca + Mg + Cu + Zn. While adding S nutrient from ZA reduced the amount of transported N during harvesting. Adding straw, manure, and Ca + Mg can increase the P nutrient transported during harvesting. The organic materials (straw and manure), Ca + Mg were likely to increase the soil pH, so that P was more available. Adding organic matter in (straw and manure) will

Table 3. The effect of integrated nutrient management on the weight of dry straw and dry grain in Margodadi, Metro Barat, Lampung, dry season 2006.

Treatment	Weight of dry straw	Weight of dry grain harvest
	……………………. Mg ha^{-1}	………………………
NPK	5.52 ab	7.44 a
NP + 5 Mg ha^{-1} straw	4.93 b	7.22 a
N½PK + 2 Mg ha^{-1} manure	5.89 a	7.44 a
NPK + (Ca + Mg)	5.59 ab	7.93 a
NPK + (Ca+Mg) + S_{ZA}	5.26 ab	7.41 a
NPK + (Ca+Mg) + S_{ZA} + Cu	5.67 ab	7.26 a
NPK + (Ca+Mg) + S_{ZA} + Zn	5.78 a	7.85 a
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	5.67 ab	7.26 a
NP+ 5 Mg ha^{-1} straw +(Ca+Mg) + S_{ZA} +Cu + Zn	5.78 a	7.70 a
N½PK+ 2 Mg ha^{-1} manure+ (Ca+Mg) + S_{ZA} + Cu + Zn	5.48 ab	7.30 a

Note: * numbers in the same column followed by same letter mean do not differ according to DMRT at 5% level.

increase the amount of transported K nutrient during harvesting. While adding Cu nutrients will exactly decrease the amount of K nutrient transported by the straw during harvest time. If the remaining rice straw was returned into the rice field, the balance of N and K nutrients were positive and it will reduce the amount of N and K fertilization. Five years incorporating straw in California reduced the dosage of N fertilizer up to 50%, and K fertilization had no response to the land with 2 years straw incorporation (Byous *et al*. 2004).

Nutrient balance was calculatied by substracting the nutrient added (input) with the amount of transported nutrient by straw and grain (output). Balanced fertilization is a condition where the nutrient balance is nearest to zero. Based on the results of N nutrient balance calculations, the NPK + (Ca + Mg) + S_{ZA} + Cu treatment was the most balanced treatment (Table 4). Based on the P nutrient balance, the NPK, NP + 5 Mg ha^{-1} straw, and NP + 5 Mg ha^{-1} straw + (Ca + Mg) + S_{ZA} + Cu + Zn treatment was the balance treatment. Meanwhile, the NPK treatment was the most balanced treatment, based on the calculation of K nutrient balance.

Experiment in Mulyosari

Adding Cu and Zn separately was likely to increase the dry weight of hybrid rice straw (statistically unsignificantly different) in Mulyosari (Table 5). Adding manure and reducing a half dosage of P fertilizer tend to increase the weight of dry straw. Adding straw, Ca, Mg, S showed no effect to the weight of dry straw.

Statistically, integrated nutrient management had not affected the dry weight of grain (Table 5). The weight of dry grain (in the straw treatment without adding KCl fertilizer) was equal to the NPK treatment. It means that rice straw can substitute 80 kg ha^{-1} KCl fertilizer. Adding Ca and Mg also had no effects to dry weight of grain. This might be due to the high Ca saturation in the soil, *i.e.* 72%. So, adding S, Zn and Cu nutrient did not increase the production of rice yield. It seems that the level of S, Zn and Cu in the soil was highly available.

Nutrients transported by straw and grain were presented in Table 6. N nutrient transported was varied between 114-169 kg ha^{-1}, P nutrient was ranged between 26 and 35 kg ha^{-1}, and K nutrient ranged between 71 and 92 kg ha^{-1}.

Based on the N nutrient balance, NPK + (Ca + Mg) + S_{ZA} and NPK + (Ca + Mg) + S_{ZA} + Cu + Zn treatment, the balance of P and K nutrients in the NPK treatment was the most balanced treatment. The P nutrient balance was varied from -10 to -19 kg ha^{-1}. K nutrient balance varied from -31 to -60 kg K ha^{-1}. If the straw removed from the paddy field, the K

Table 4. The nutrients balance calculation of N, P, and K in rice field in Margodadi, Metro Barat, Lampung, dry season 2006.

Treatment	Input	Output	Balance
	……………..kg ha^{-1} N ……………		
NPK	135	105	30
NP + 5 Mg ha^{-1} straw	191	123	68
N½PK + 2 Mg ha^{-1} manure	150	137	13
NPK + (Ca + Mg)	135	147	-12
NPK + (Ca+Mg) + S_{ZA}	146	137	8
NPK + (Ca+Mg) + S_{ZA} + Cu	146	143	3
NPK + (Ca+Mg) + S_{ZA} + Zn	146	152	-6
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	146	137	8
NP+ 5 Mg ha^{-1} straw + (Ca+Mg) + S_{ZA} + Cu + Zn	202	150	52
N½PK+ 2 Mg manure + (Ca+Mg) + S_{ZA} + Cu + Zn	168	142	25
	……………kg ha^{-1} P ……….		
NPK	20	28	-7
NP + 5 Mg ha^{-1}straw	29	36	-7
N½PK + 2 Mg ha^{-1} manure	20	34	-14
NPK + (Ca + Mg)	20	32	-12
NPK + (Ca+Mg) + S_{ZA}	20	33	-12
NPK + (Ca+Mg) + S_{ZA} + Cu	20	33	-12
NPK + (Ca+Mg) + S_{ZA} + Zn	20	36	-16
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	20	31	-11
NP+ 5 Mg ha^{-1} straw + (Ca+Mg) + S_{ZA} + Cu + Zn	29	35	-6
N½PK+ 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	20	35	-15
	…………kg ha^{-1} K ……….		
NPK	60	106	-47
NP + 5 Mg ha^{-1} straw	109	114	-5
N½PK + 2 Mg ha^{-1} manure	89	125	-36
NPK + (Ca + Mg)	60	128	-68
NPK + (Ca+Mg) + S_{ZA}	60	114	-54
NPK + (Ca+Mg) + S_{ZA} + Cu	60	94	-34
NPK + (Ca+Mg) + S_{ZA} + Zn	60	114	-54
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	60	119	-60
NP+ 5 Mg straw + (Ca+Mg) + S_{ZA} + Cu + Zn	109	125	-17
N½PK+ 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	89	112	-23

Table 5. The effect of fertilization on weight of dry straw and the weight of dry grain in Mulyosari, Metro, Lampung, dry season 2006.

Treatment	Weight of dry	Weight of dry grain harvest
	……………………Mg ha^{-1}………………….	
NPK	4.33 bc	7.00 a
NP + 5 Mg ha^{-1} straw	4.41 bc	7.00 a
N½PK + manure	5.07 ab	7.18 a
NPK + (Ca + Mg)	4.41 ab	6.89 a
NPK + (Ca+Mg) + S_{ZA}	4.89 ab	7.15 a
NPK + (Ca+Mg) + S_{ZA} + Cu	5.48 a	7.78 a
NPK + (Ca+Mg) + S_{ZA} + Zn	5.22 a	7.39 a
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	4.78 ab	7.22 a
NP + 5 Mg ha^{-1} straw. + (Ca+Mg) + S_{ZA} + Cu + Zn	3.85 c	7.15 a
N½PK+ 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	4.44 bc	7.34 a

Note: * numbers in the same column followed by same letter mean do not differ according to DMRT at 5% level.

Table 6. The calculation of the balance of N, P, and K nutrient on lowland rice which has a high status of P and K in Lampung, dry season 2006.

Treatment	Input	Output	Balance
		...............kg N ha^{-1}............	
NPK	135	114	21
NP + 5 Mg ha^{-1} straw	191	128	63
N½PK + 2 Mg ha^{-1} manure	187	143	44
NPK + (Ca + Mg)	135	129	6
NPK + (Ca+Mg) + S_{ZA}	146	142	3
NPK + (Ca+Mg) + S_{ZA} + Cu	146	169	-23
NPK + (Ca+Mg) + S_{ZA} + Zn	146	154	-8
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	146	141	4
NP+ 5 Mg ha^{-1} straw + (Ca+Mg) + S_{ZA} + Cu + Zn	202	135	67
N½PK + 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	198	147	50
		...........kg P ha^{-1}.......	
NPK	16	26	-10
NP + 5 Mg ha^{-1} straw	21	34	-13
N½PK + 2 Mg ha^{-1} manure	16	33	-17
NPK + (Ca + Mg)	16	31	-16
NPK + (Ca+Mg) + S_{ZA}	16	32	-17
NPK + (Ca+Mg) + S_{ZA} + Cu	16	35	-19
NPK + (Ca+Mg) + S_{ZA} + Zn	16	34	-18
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	16	32	-16
NP+ 5 Mg ha^{-1} straw + (Ca+Mg) + S_{ZA} + Cu + Zn	21	31	-11
N½PK + 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	16	33	-18
		.... kg K ha^{-1}.........	
NPK	40	71	-31
NP + 5 Mg ha^{-1} straw	27	87	-60
N½PK + 2 Mg ha^{-1} manure	54	88	-34
NPK + (Ca + Mg)	40	78	-38
NPK + (Ca+Mg) + S_{ZA}	40	86	-46
NPK + (Ca+Mg) + S_{ZA} + Cu	40	92	-52
NPK + (Ca+Mg) + S_{ZA} + Zn	40	87	-47
NPK + (Ca+Mg) + S_{ZA} + Cu + Zn	40	87	-47
NP+ 5 Mg ha^{-1} straw + (Ca+Mg) + S_{ZA} + Cu + Zn	27	71	-44
N½PK + 2 Mg ha^{-1} manure + (Ca+Mg) + S_{ZA} + Cu + Zn	54	82	-28

nutrient balance was -72 kg K ha^{-1} and if the straw was returned to the paddy field the K nutrient balance was -2.4 K kg K ha^{-1} (Fairhurst 2002). If the rice straw was returned into the rice field, the K nutrient balance was ranged from 11 to 40 kg K ha^{-1}.

Based on the N nutrient balance, NPK + (Ca + Mg) + S_{ZA} and NPK + (Ca + Mg) + S_{ZA} + Cu + Zn treatment, the balance of P and K nutrients in the NPK treatment was the most balanced treatment. The P nutrient balance was varied from -10 to -19 kg ha^{-1}. K nutrient balance varied from -31 to -60 kg K ha^{-1}. If the straw removed from the paddy field, the K nutrient balance was -72 kg K ha^{-1} and if the straw was returned to the paddy field the K nutrient balance was -2.4 K kg K ha^{-1} (Fairhurst 2002). If the rice straw was returned into the rice field, the K nutrient balance was ranged from 11 to 40 kg K ha^{-1}.

CONCLUSIONS

Returning 5 Mg ha^{-1} rice straw to the rice field can substitute the role of KCl fertilizer equivalently to 80 kg ha^{-1} in Mulyosari and 120 kg ha^{-1} in Margodadi. Addition of 2 Mg ha^{-1} cow manure can substitute ½ dosage of P. The grain yield was not significantly different to the NPK treatment.

Good nutrient management in the Lampung rice field was by adding N, P, and K based on the soilnutrient status and the crop needs. Incorporating rice straw can reduce the dosage of N and K fertilizer.

Organic materials addition of like cow manure as well as dolomite fertilizers can increase N, P, and K nutrient taken out on harvesting.

Nutrient balance of P and K was on negative status, but the balance of N, P, and K nutrients can be improved to become positive by returning the rice straw into the paddy field.

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