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Plot scale nitrogen balance of newly opened wetland rice at Bulungan District

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Developing of newly opened wetland rice is one of the Indonesian major concerns to meet the rice growing demand, keep food security and generate farmers' income. Study on plot scale nitrogen balance of newly opened wetland rice conducted in Panca Agung village, Bulungan District, East Kalimantan in 2009 was not only to validate the nitrogen fertilizer application rate, but also to provide nitrogen fertilizer during planting season and to sustain rice production. Nitrogen balance was computed according to the differences between nitrogen gains and losses. The results indicated that positive nitrogen balances were taken place in all treatments meaning that surplus nitrogen fertilizer application. Economically and environmentally was considered high cost and caused water pollution. Application of rice straw compost was not only contributed to nitrogen inputs and other nutrient, but also may create better soil condition for microbial activity. To avoid any negative impacts, in term of environmental, agronomical and economic point of views, the recommended urea application rate should be reduced from 250 to 200 kg ha^{-1} season^{-1} with adding compost of about 3000 kg ha^{-1} season^{-1}.

Keywords: Nitrogen balance, plot scale, nitrogen inputs, nitrogen losses, newly opened wetland rice.

INTRODUCTION

It is coming to realise that the Indonesian Agriculture challenge a head especially in food is producing more rice with limited land and water due to increasing population, land conversion to housing and industrial areas, water competition between agricultural and industrial as well as domestic purposes, and water pollution. To meet the rice growing demand, development of newly opened wetland rice fields in outside Java and Bali Islands is becoming one of the priorities of agriculture development program. Highly weathered soils, especially ultisols and oxisols are mainly granted for extending newly opened wetland rice areas, besides potential acid sulphate soil. These soils are acidic with have low natural level of major plant nutrients, but they have Al, Mn and Fe in toxic levels (Table 1). Theoretically, the nutrients level of these soils can be effectively improved with mineral fertilizers. However, for the smallholder farmers for instance farmers living in transmigration areas the costs to purchase the mineral fertilizers are problem. The chemical fertilizer in sufficient quantity is beyond the financial reach of smallholder farmers. So far, practically to sustain crop production, proper management practices using more organic matter plus liming, and application of appropriate inorganic fertilizer is often recommended (Sukristiyonubowo and Tuherkih, 2009; Yan et al., 2007; Fageria and Baligar, 2001; Sukristiyonubowo et al., 1993). Therefore, it is urgent to assess nutrient input given to the field and nutrient taken away from the field to get appropriate nutrients management. Since, quantification of nutrient inputs and outputs is important for agronomical, economical and environmental analyses.

By definition, nutrient balances are the differences between nutrient gains and losses. The inputs include nutrients coming from fertilizers, returned crop residues, irrigation, rainfall, and biological nitrogen fixation (Sukristiyonubowo et al., 2010; Sukristiyonubowo, 2007; Wijnhoud et al., 2003; Lefroy and Konboon, 1999; Miller and Smith, 1976). According to Sukristiyonubowo et al.

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Table 1. Chemical and physical soil properties of newly opened wetland rice in Tanjung Palas Utara Sub district, Bulungan District established in 2007 (Source: Sukristiyonubowo *et al.,* 2011b)

Soil Parameters	Unit	Value	Criteria
pH H_2O		4,62 – 4,70	Very acid
Organic Matter:			
C-organic	%	0.71 – 1.29	Very low
N Total	%	0.03 – 0.05	Very low
C/N ratio		20 - 26	
P Total (HCl 25 %)	ppm	31 -58	Very low
K Total (HCl 25 %)	ppm	55 - 138	Low
P Bray I	ppm	1.09 – 2.69	Very low
CEC	cmol (+) kg^{-1}	5.81 – 9.53	Low
Base Saturation	%	16 - 39	Low
K	cmol (+) kg^{-1}	0.05 – 0.11	Very low
Ca	cmol (+) kg^{-1}	1.04 – 1.83	Very low
Mg	cmol (+) kg^{-1}	0.21 – 0.27	Low
Na	cmol (+) kg^{-1}	0.05 – 0.19	Low
Fe	ppm	170 - 210	High
Mn	ppm	50.40	High
Texture 1:			Silty Clay Loam
Sand	%	6.1	
Silt	%	64.8	
Clay	%	29.1	
Texture 2:			Clay
Sand	%	1.3	
Silt	%	18.3	
Clay	%	80.4	

(2010), Sukristiyonubowo (2007) and Uexkull (1989), the outputs include removal through harvested biomass (all nutrients), erosion (all nutrients), leaching (mainly nitrate, potassium, calcium and magnesium), fixation (mainly phosphate), and volatilisation (mainly nitrogen and sulphur). When the nutrient removals are not replaced by sufficient application of fertilizers or returning of biomass, soil mining takes place and finally crop production do not reach its potential yields and reduces.

Nutrient balances can be developed at different scales, including (a) plot, (b) field, farm or catchment, (c) district, province, and (d) country scale, and for different purposes (Sukristiyonubowo et al., 2010; Lefroy and Konboon, 1999; Bationo et al., 1998; Hashim et al., 1998; Van den Bosch et al., 1998a and 1998b; Syers .1996; Smaling et al., 1993; and Stoorvogel *et al.,* 1993). Many studies indicate that at plot, farm, district, province, and national levels, agricultural production is characterised by a negative nutrient balance (Sukristiyonubowo et al., 2010; Sukristiyonubowo, 2007; Nkonya et al., 2005; Sheldrick et al., 2003; Harris. 1998; Van den Bosch et al., 1998b). A long-term nitrogen experiment at plot scale in the dry land sloping area of Kuamang Kuning, Jambi Province, Indonesia provided confirmation that the balance in the plots without input was - 4 kg N ha^{-1} yr^{-1}. However, this do not happen in the plots treated with a combination of high fertilizer application rates and *Flemingia congesta* leaves planted in a hedge row system (Santoso et al., 1995).

Practically, a complete study of nutrient balances is very complicated. In a simple approach, nutrient loss is mainly calculated based on removal by harvested products and unreturned crop residues, while the main inputs are organic and mineral fertilizers. So far, it is reported that most assessment is partial analysis of these in- and output data (Wijnhoud et al., 2003; Drechsel et al., 2001; Lefroy and Konboon, 1998).

Crop residue is a fundamental natural resource for conserving and sustaining soil productivity. It supplies essential plant nutrients, improves chemical, physical and biological conditions of the soil, and prevents soil degradation (Aulakh et al., 2001; Puget and Drinkwater, 2001; Jastrow et al., 1998; Walter et al., 1992; Tisdale and Oades, 1979). However, the nutrients present in roots often have been ignored in assessment of cropping systems. Most attention is paid to cover crops since they

Table 2. The detail treatment of the effect of NPK fertilization, dolomite and compost made of straw on soil chemical properties and rice yield of newly opened rice fields (in kg ha^{-1} $season^{-1}$).

Code	Treatment	Urea	SP-36	KCl	Dolomite	Compost
T0	Farmer Practices (as control)	100	100	-	-	-
T1	Farmer Practices + Compost + Dolomite	100	100	-	2000	2000
T2	NPK with recommendation rate	250	100	100	-	-
T3	NPK with recommendation rate (N and K were split 3 x)	250	100	100	-	2000
T4	NPK with recommendation rate + Compost + Dolomite (N and K were split 3x)	250	100	100	2000	2000
T5	NPK with recommendation rate + Compost + Dolomite	250	100	100	2000	2000

are considered to be a potential source of nitrogen for the following crops (Kumar and Goh, 2000; Thomsen, 1993; Harris and Hesterman, 1990). Now, it has been observed that the contribution of plant nutrients from roots is important, ranging between 13 and 40 % of total plant N (Sukristiyonubowo et al., 2010; Chaves et al., 2004; Kumar and Goh, 2000).

This paper discussed only the nitrogen balance of newly opened wetland rice field at Bulungan district, with the aims were (1) to evaluate nitrogen input – out of newly opened wetland rice under different treatments, (2) to validate the nitrogen fertilizer rate, and (3) to estimate how much nitrogen fertilizers should be provided at the Bulungan district every planting season. It was hypothesized that by determining the proper nitrogen fertilizer application rate, the balance nitrogen and optimal rice yield at newly opened wetland rice fields can be reached and nitrogen fertilizer stock for the Bulungan district fulfilled every planting season.

METHODOLOGY

Field experiment was carried out in newly opened wetland rice at Panca Agung Village, Bulungan District, and East Kalimantan Province in 2009. The site was relatively flat and developed two years ago in 2007. Six treatments were tested namely T0: farmers practices (as control), T1: farmer practices + straw compost + dolomite, T2: NPK with recommendation rate, in which N and K were split two times, T3: NPK with recommendation rate, in which N and K was split three times, T4: NPK with recommendation rate in which N and K were split three times + straw compost + dolomite and T5: NPK with recommendation rate in which N and K were split two times + straw compost + dolomite. They were arranged into Randomized Complete Block Design (RCBD) and replicated three times. The plot sizes were 5m x 5m with the distance among plot was 50 cm and between replication was 100 cm. NPK fertilizer used originated from single fertilizer namely urea, SP-36 and KCl. Based on the direct measurement with Soil Test Kits, the recommendation rate was about 250 kg urea, 100 kg SP-36 and 100 kg KCl ha^{-1}, while the farmer practices rate was 100 kg urea and 100 kg SP-36 ha^{-1}. For treatment T2 and T5, urea and KCl were applied two times, 50% at planting time and 50% at 21 days after transplanting (DAT). For the treatment T3 and T4, urea and KCl were split three times namely 50 % at planting time, 25 % at 21 DAT and the last 25 % was given at 35 DAT. Dolomite as much as two tons ha^{-1} and rice straw compost of about two tons ha^{-1} were broadcasted a week before planting. Before broadcasting the compost, one kg composite compost were taken and submitted to Bogor for nutrient analysing. The detail treatment is presented in Table 2.

Ciliwung rice variety was cultivated as plant indicator. Transplanting was conducted in the end of June 2009 and harvest in the beginning of October 2009. Twenty-one-day old seedlings were transplanted at about 25 cm x 25 cm cropping distance with about three seedlings per hill. Rice biomass productions including grains, straw, and residues were observed. On a hectare basis, they were extrapolated from sampling areas of 1m x 1m. These sampling units were randomly selected at every plot. Rice plants were cut about 10 to 15 cm above the ground surface. The samples were manually separated into rice grains, rice straw, and rice residues. Rice residues included the roots and the part of the stem (stubble) left after cutting. Fresh weights of rice grain, rice straw, and rice residue were immediately weighed at each sampling unit. In the input-output analysis, rice residue was not considered as input, as according to the farmers, rice residue was always remained in the field. This was similar to the farmers in Semarang District (Sukristiyonubowo, 2007).

The nutrient inputs were the sum of nutrients coming from mineral fertilizer (IN-1), rice straw compost (IN-2), irrigation (IN-3), and precipitation (IN-4). Outputs were sum of nutrients removed by rice grains (OUT-1) and rice straw (OUT-2). See formulas 1, 2 and 3.

Nitrogen Inputs (IN) = IN-1 + IN-2 + IN-3 + IN-4 ……..(1)
Nitrogen Outputs (OUT) = OUT-1 + OUT-2 .... (2)
Nitrogen Balance= IN– OUT …………………………...(3)

To quantify nitrogen gain, data included concentration of nitrogen in urea, rate of urea application, amount of organic fertilizer, irrigation water supply, nitrogen concentrations in irrigation waters, and in rainfall were collected. The output parameters were rice grain yields, rice straw production, nitrogen concentrations in rice grain and rice straw.

IN-1 and IN-2 was calculated based on the amount of mineral and organic fertilizers added multiplied by the concentration of nitrogen in urea and compost, respectively.IN-3 was estimated according to water input and nutrients content in irrigation water. Water input was the different berween incoming water and out going water. Incoming water was calculated by mean of water debit multiplied with how long the farmer open and close the inlet and outlet during rice life cycle. As the nutrient concentration from the outlet was not measured, thus the contribution of irrigation water was predicted based on water input multiplied by the nitrogen content in the incoming water. In this experiment, the ponding water layer was maintained about three cm. The water debit was measured using Floating method with stop watch (World Meteorological Organisation. 1994) Detail procedure can be seen in Sukristiyonubowo (2007). IN-4 was estimated by multiplying monthly rainfall volume with nutrient concentrations in the rain water. In a hectare basis, it was counted as follow:

$$\text{IN-4} = \frac{A \times 10.000 \times 0.80 \times B \times 1000}{1000 \times 10^6}$$

Where:

- IN-4 is nitrogen contribution of rainfall water in kg N ha^{-1} $season^{-1}$
- A is rainfall in mm
- 10000 is conversion of ha to m^2
- 0.80 is factor correction, as not all rain water goes in the soil
- B is nitrogen concentration in rainfall water in mg l^{-1}
- 1000 is conversion from m^3 to l
- 1000 is conversion from mm to m
- 10^6 is conversion from mg to kg

To monitor rainfall events, data from rain gauge and climatology station of Bulungan were considered. Rain waters were sampled once a month from a rain gauge in 600 ml plastic bottles and was also analysed according to the procedures of the Laboratory of the Soil Research Institute, Bogor.

Theoretically, the nitrogen loss can be through harvested product (rice grain and rice straw), leaching and ammonia volatilization. Due to leaching and ammonia volatilisation was not yet measured, thus the nitrogen loss was only from harvested product. Thus, the total nitrogen output was bit underestimated. As all rice grains are consumed, OUT-1 was estimated based on rice grain yield multiplied with nutrient concentration in the grains. OUT-2 was calculated according to the total rice straw production multiplied with nutrient concentration in the straw. It was considered as output because all rice straw was taken out from the field for making compost and the compost will be applied for coming planting season.

Plants were sampled at harvest and were collected from every plot, one hill per plot. After pulling out, the plant roots were washed with canal water. For the laboratory analyses, the samples were treated according to procedures of the Analytical Laboratory of the Soil Research Institute, Bogor. Samples were washed with deionised water to avoid any contamination, and dried at 70^0 C. The dried samples were ground and stored in plastic bottles. Nitrogen was determined by wet ashing using concentrated H_2SO_4 (97%) and selenium (Soil Research Institute, 2009).

RESULTS AND DISCUSSION

The nitrogen balance at plot scale was constructed according to the different between nitrogen input and nutrient loss. When the balance is negative meaning that nutrient input is deficit, and it has to be added more fertilizers to avoid soil nutrients mining. However, when the balance is positive the nutrient input is surplus and the fertilizers application should be reduced to prevent environmental risks.

Nitrogen Gain

The nitrogen input originated from application rate of urea (IN-1), compost (IN-2), irrigation water (IN-3) and rainfall water (IN-4) and their nutrient contribution was presented in Table 3 and Table 4. The IN-1 (contribution of inorganic fertilizer) ranged from + 45.00 to + 112.50 kg N ha^{-1} $season^{-1}$ depending on the treatment. It can be said that the higher the rate of urea fertilizer, the higher the nitrogen contribution to the input (Table 3). However, this did not mean that the excess urea application was recommended since pollution in ground and surface waters as well as increasing agriculture input cost should be taken into account. Many scientists reported that over application of nitrogen fertilizer does not only result in accumulation of NO_3-N in the soil profile, but also elevate NO_3-N concentration in ground water and drinking water and increase production cost (Sukristiyonubowo et al., 2011a; Marie et al., 2006; Nixon et al., 2003; Meisinger and Kandall, 1991).

Table 3. The contribution of inorganic fertilizer (IN-1) and compost (IN-2) to nutrient input of newly opened wetland rice at Bulungan District.

Code	Treatment	Rate and contribution of urea (kg ha^{-1})		Rate and contribution of compost (kg ha^{-1})	
		Rate	IN-1	Rate	IN-2
T0	Farmer Practices (as control)	100	45.00	-	0.00
T1	Farmer Practices + Compost + Dolomite	100	45.00	2,000	20,60
T2	NPK with recommendation rate	250	112.50	-	0.00
T3	NPK with recommendation rate (N and K were split 3 x)	250	112.50	-	0.00
T4	NPK with recommendation rate + Compost + Dolomite (N and K were split 3x)	250	112.50	2,000	20,60
T5	NPK with recommendation rate + Compost + Dolomite	250	112.50	2,000	20,60

Table 4. The contribution of irrigation (IN-3) and rainfall water (IN-4) to nutrient input of newly opened wetland rice at Bulungan District (kg N ha^{-1}).

Treatment	water input, $NH4^{+}$ and NO_3^{-} concentration				Rainfall		
	Water input (L)	$NH4^{+}$ (mg l^{-1})	NO_3^{-} (mg l^{-1})	IN-3 (kg N ha^{-1})	Rainfall (mm yr^{-1})	$NH4^{+}$ (mg l^{-1})	IN-4 (kg N ha^{-1})
T0	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37
T1	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37
T2	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37
T3	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37
T4	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37
T5	15×10^{6}	0.77	0.92	23.76	2715.10	0.91	15.37

T0: Farmer Practices (as control)
T1: Farmer Practices + Compost + Dolomite;
T2: NPK with recommendation rate
T3: NPK with recommendation rate (N and K were split 3 x)
T4: NPK with recommendation rate + Compost + Dolomite (N and K were split 3x)
T5: NPK with recommendation rate + Compost + Dolomite

Meanwhile, the IN-2 (contribution of compost) was about 20.60 kg N ha^{-1}, from the mean of nitrogen contents in compost of 1.52 %, 0.93 % and 0.63 % N. Hence, besides the amount of compost, the nitrogen concentration in compost influences its contribution. In addition, the present of compost also create better soil function, reduce free Fe through chelating and enhance microbial activity resulting in more available nutrients. Consequently, the present of compost can reduce the nitrogen application rate.

The nitrogen input from irrigation water (IN-3) was about 23.76 kg N equivalent to about 50 kg urea and the input from rainfall water was about 15.37 kg N, equal to 33 kg urea (Table 4). These data provided information that their contributions were considered significant to the total input, meaning that in the wet season we can also reduce the nitrogen fertilizer to minimize the agriculture input cost.

Nitrogen loss

To calculate the nitrogen loss, data of rice biomass production namely rice grain yield and rice straw production and nitrogen concentration in rice grain and rice straw were gathered. The nitrogen loss was estimated from nitrogen taken away from rice grain (OUT-1) as all rice grain was consumed and nitrogen taken out by rice straw (OUT-2). The nitrogen loss is presented in Table 5.

Output-Input Analysis

The N balance of newly opened wetland rice is presented in Table 6. In general, the results indicate that inorganic fertilizer (IN-1) contributes considerably to total nitrogen input in all treatments. The amounts varied from 45.00 to

Table 5. Rice biomass production including rice grain and rice straw of Ciliwung variety and total nitrogen loss from rice grain (OUT-1) and rice straw (OUT-2) at newly opened wetland rice of Panca Agung site, Bulungan District

Treatment	Biomass Production (t $ha^{-1}season^{-1}$)		N concentration (%)		Nitrogen loss (kg N $ha^{-1}season^{-1}$)	
	Rice Grain	**Rice Straw**	**Rice Grain**	**Rice Straw**	**OUT-1**	**OUT-2**
T0	2.51 d	3.83 b	1.12	0.88	28.11	33.70
T1	2.97 cd	3.94 b	1.19	0.63	35.34	24.82
T2	3.09 bc	5.02 a	1.16	0.87	35.84	43.67
T3	3.68 abc	4.64 ab	1.21	0.87	44.53	40.37
T4	4.29 a	5.20 a	1.28	0.90	54.91	46.80
T5	3.80 ab	5.24 a	1.22	0.72	46.36	37.73
CV (%)	20.41	15.47				

T0: Farmer Practices (as control); T1: Farmer Practices + Compost + Dolomite;
T2: NPK with recommendation rate
T3: NPK with recommendation rate (N and K were split 3 x)
T4: NPK with recommendation rate + Compost + Dolomite (N and K were split 3x)
T5: NPK with recommendation rate + Compost + Dolomite

Table 6. Output-input analysis for nitrogen of newly opened wetland rice of Panca Agung site, Bulungan District (kg N ha^{-1} $season^{-1}$)

Parameter	Treatments					
	T0	**T1**	**T2**	**T3**	**T4**	**T5**
N INPUT (kg N ha^{-1} $season^{-1}$) **:**						
IN-1	45.00 *(54%)*	45.00 *(43%)*	112.50 *(74%)*	112.50 *(74%)*	112.50 *(65%)*	112.50 *(65%)*
IN-2	0.00 -	20.60 *(20%)*	0.00 -	0.00	20.60 *(12%)*	20.60 *(12%)*
IN-3	23.76 *(28%)*	23.76 *(23%)*	23.76 *(16%)*	23.76 *(16%)*	23.76 *(14%)*	23.76 *(14%)*
IN-4	15.37 *(18%)*	15.37 *(15%)*	15.37 *(10%)*	15.37 *(10%)*	15.37 *(9%)*	15.37 *(9%)*
Total N Input	84.13 *(100%)*	104.73 *(100%)*	151.63 *(100%)*	151.63 *(100%)*	172.23 *(100%)*	172.23 *(100%)*
N OUPUT (kg N ha^{-1} $season^{-1}$)**:**						
OUT-1	- 28.11 *(45%)*	- 35.34 *(59%)*	- 35.84 *(45%)*	- 44.53 *(52%)*	- 54.91 *(54%)*	- 46.36 *(55%)*
OUT-2	- 33.70 *(55%)*	- 24.82 *(41%)*	- 43.67 *(55%)*	- 40.37 (48%)	- 46.80 (46%)	- 37.73 *(45%)*
Total N Output	-61.81 *(100%)*	- 60.16 *(100%)*	- 79.51 *(100%)*	- 84.90 *(100%)*	- 101.71 *(100%)*	- 84.09 *(100%)*
N Balance	+ 22.32	+ 44.57	+ 72.12	+ 66.73	+ 70.52	+ 88.14

Note: the number with percentage in the same column indicated the nitrogen contribution to the total nitrogen input

112.50 kg N ha^{-1} $season^{-1}$ depending on the treatment. In the NPK with recommended application rate (T2 to T5) treatments, IN-1 covered from 65 % to 74 % of total N. Meanwhile in the farmer practices rates (T0 and T1), they contributed from 43 to 54 % to the total N inputs. Therefore, it can be said that inorganic fertilizers are the most important nitrogen sources to manage wetland rice field. This means that the needs for nitrogen fertilizer may be greater in the newly opened wetland rice areas than in other wetland rice fields as in the newly opened wetland rice plough pan was not established resulting in more nitrogen was leached (Agus. 2007; Prasetyo. 2007). Furthermore, nitrogen content in newly wetland rice field was low. Consequently, application of compost making from rice straw is not only created better soil function, but also contributed significant to nitrogen. Thus, contribution of compost (IN-2) was important, varying from 12 to 20 % of total N depending on the treatment or application rate. The IN-2 inputs were getting more important, when less or no inorganic fertilizers were applied and more organic fertilizer is added, like in semi and fully organic rice farming system. The N supplied by compost was equivalent to 45 kg of urea and will be more when the rate of application is increase.

Although the amounts of nutrients coming from irrigation water (IN-3) were smaller compared to the amounts of nutrients originating from nitrogen fertilizer (IN-1) and more or less comparable with organic fertilizer (IN-2), the contributions of IN-3 to total N inputs were still important, covering between 14 % and 28 % of the total N input. Increasing of inorganic fertilizer and compost application rate reduced the role of IN-3 to the total N input like in T4 and T5.

IN-4 (contribution of rainfall water) was about 15.37 kg N ha^{-1} equal to about 34 kg urea (45%) and considered an important nitrogen source, particularly during the wet season. The contribution ranged from 9 to 18 % of the total of N input.

With respect to the output, depending on the treatment, around 45 % - 59 % of total N was taken up by rice grains and the rest by rice straw. This means that N was rather equally removed by rice straw and rice grains and will not be the same when the rice grain increased.

Assessment of nitrogen input and output shows a positive balance for all treatments both (Table 6). The surplus ranged between 22.32 and 88.14 kg N ha^{-1} $season^{-1}$, depending on the treatment. The N balances in the T4 and T5 were more positive than in the other treatmens. This may be explained by increasing of mineral fertilizers' rate, although the rice grain and straw productions were higher than others. It should also be noted that the N output will even be higher, when NH_3 volatilisation and leaching are taken into account.

The positive N balances in all treatments also demonstrated that the application rates of nitrogen fertilizers were more than sufficient to fix N removed by grains and straw. However, we do believe that when the rice grain increase and NH_3 volatilisation and leaching are taken into account, the balance will move. Therefore, to avoid luxury consumption and to protect environment as well as to reduce the production cost, the nitrogen fertilizer application rate could be between 150 to 200 kg of urea ha^{-1} $season^{-1}$, which implies an increase of about 1000 to 2000 kg of compost to increase and sustain a higher rice grain yield, at least it is higher than 4.29 t ha^{-1} $season^{-1}$.

Implementation and Recommendations

As sometime it was not easy to get the urea during planting time and the price was considered higher than normal price, providing urea based on total planted areas or existing wetland rice areas and urea application rate is very important. According to anonymous (2010) the total wetland rice areas in Bulungan district is about 9,849 ha, therefore, total urea should be available is about 1,970 tons $district^{-1}$ $season^{-1}$ (200 kg x 9,849 ha). It is also important to provide the district regulation about not to burn the rice straw but to be returned as compost. Consequently, training on making local microorganism and compost should be encouraged to the farmers and agricultural extension.

CONCLUSION

Assessment of nitrogen input and output of newly wetland rice in Bulungan District indicate the surplus N meaning that urea application rate is higher than the nitrogen taken out by harvest product. Regarding the environmental, agronomical and economic aspects, the rate can be reduced to 200 kg urea ha^{-1} $season^{-1}$.

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