Rice Yield and Nutrient Removal through Harvest in Newly Developed Lowland Rice Field in Bulungan District, North Kalimantan

Hasil Padi dan Unsur Hara yang Terangkut Bersama Panen pada Sawah Bukaan Baru di Kabupaten Bulungan, Kalimantan Utara

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Abstract. Nutrient removal through rice harvest of Ciherang variety planted in newly developed lowland rice field was studied in Bulungan District, in 2013. The aims of this research were to evaluate the amount of nutrients taken out by rice harvest and to properly manage its fertility to sustain high rice yield. Five treatments were tested, T0: Farmers practices, T1: Package A (NPK at recommendation r ate + Dolomite), T2: Package B (NPK at recommendation rate + dolomite + Compost + Smart), T3: Package C (¾ NPK at recommendation rate + Compost + Dolomite + Smart), and T4: Package D (NPK at recommendation rate + Compost + Dolomite + Smart). They were arranged in a Randomized Complete Block Design and replicated three times. The results showed that the highest rice biomass yield (rice grains, rice straw and rice residues) was from the package D, whereas, the highest concentrations of N, P, and K were found in rice grain of Package B. The highest nitrogen and phosphorous removals were from rice grains and for potassium was from rice straw. Depending on the treatments, total nutrient removal through rice grains and rice straw varied: from 30.96 ± 2.93 to 67.82 ± 8.93 kg of N; 12.83 ± 2.15 to 27.53 ± 14.11 kg of P; and 55.10 ± 2.92 to 101.84 ± 6.02 kg of K ha^{-1} $season^{-1}$. To avoid nutrient mining and to maintain the soil fertility, about 67 to 150 kg urea, 65 to 140 kg SP-36 and 105 to 196 kg KCl ha^{-1} $season^{-1}$ should be applied to the soil.

Abstrak. Unsur hara yang terangkut oleh hasil panen padi varitas Ciherang yang ditanam pada sawah bukaan baru dipelajari dan diteliti di Kabupaten Bulungan, Kalimantan Utara pada tahun 2013. Penelitian bertujuan untuk mengetahui unsur hara yang diangkut oleh hasil panen dan untuk meningkatkan status unsur hara agar diperoleh hasil padi yang tinggi. Lima macam perlakuan dibandingkan, T0: Kebiasaan Petani, T1: Paket A (NPK dengan dosis rekomendasi + Dolomit), T2: Paket B (NPK dengan dosis rekomendasi + dolomit + kompos jerami + Smart), T3: Paket C (¾ dosis rekomendasi NPK + kompos jerami + Dolomit + Smart), dan T4: Paket D (NPK dengan dosis rekomendasi + kompos jerami + Dolomit + Smart). Perlakuan disusun berdasarkan Rancangan Acak Kelompok yang diulang tiga kali. Hasil penelitian menunjukkan bahwa hasil brangkasan padi (gabah, jerami dan sisa tanam padi) tertinggi diperoleh pada perlakuan paket D. Sebaliknya, konsentrasi N, P dan K tertinggi diperoleh pada paket B. Kehilangan N dan P tertinggi adalah yang terangkut bersama hasil gabah dan kehilangan K tertinggi terangkut bersama jerami padi. Tergantung pada perlakuannya, total unsur hara yang diangkut oleh hasil gabah dan jerami padi bervariasi antara 30,96 ± 2,93 sampai 67,82 ± 8,93 kg untuk N; 12,83 ± 2,15 sampai 27,53 ± 14,11 kg untuk P; dan 55,10 ± 2,92 sampai 101,84 ± 6,02 kg untuk K ha^{-1} $musim^{-1}$. Untuk menghindari pengurasan unsur hara dan menjaga kesuburan tanah, maka diperlukan penambahan 67 sampai 150 kg urea, 65 sampai 140 kg SP-36 dan 105 sampai 196 kg KCl ha^{-1} $musim^{-1}$.

Introduction

Highly weathered soils as well as potential acid sulphate soils outside Java and Bali have many short-comings. The soils are acidic with low natural level of major plant nutrients and having toxic levels of Al, Mn and Fe (Sudjadi 1984; Sukristiyonubowo *et al.* 2011). Newly developed lowland rice fields are among those with such fertility problems. Theoretically, the soil fertility status can effectively be improved with addition of mineral fertilizers and balance fertilization of N, P, and K. Balanced fertilization is also important to promote

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microbial biomass growth as well as improve microbial community composition (Dobermann *et al*. 1996; Zhang and Wang 2005). However, for the smallholder farmers including the farmers living in transmigration areas, the costs to purchase fertilizers are problematic. For those who can afford, improper and imbalanced mineral fertilization is a problem. The chemical fertilizer in enough quantity is beyond their financial reach.

To sustain crop production, proper management practices using more organic matter plus liming, and inorganic fertilizer is recommended (Fageria and Baligar. 2001; Fenning *et. al*. 2005; Yan *et al.* 2007; Sukristiyonubowo *et al.* 2012; Sukristiyonubowo *et al.* 2011; Sukristiyonubowo and Du Laing 2010; Sukristiyonubowo and Tuherkih. 2009; Sukristiyonubowo *et al*. 1993; Whitbread *et al.* 2003). Thus, we tested the promising technologies in newly opened lowland rice fields to develop soil fertility management that can be adapted and adopted by farmers.

Many researchers reported that application of mineral fertilizers increases rice yield and the responses to fertilizers vary depending on varieties, soil, climate, and cultural practices (Min *et al.* 2007; Sukristiyonubowo. 2007; Cho *et al.* 2002 and Cho *et al*. 2000; Fageria and Baligar. 2001; Soepartini, 1995; Uexkull, 1970). Many studies reported that the uptake of nutrients depends on variety, cultural practices, nutrients supply, and climate (Sukristiyonubowo and Du Liang. 2011; Sukristiyonubowo and Tuherkih. 2009; Yang *et al.* 2004; Sukristiyonubowo *et al.* 2003; Singh *et al.* 2001; Kemmler, 1971; Sanchez and Calderon, 1971; Uexkull, 1970). In accordance with variety and climate, Sukristiyonubowo (2007) and Uexkull (1970) observed that the total nutrients removals through rice grains and rice straw in the wet season ranged from 77 to 163 kg N, 14 to 16 kg P, and 150 to 198 kg K ha^{-1} $season^{-1}$ and these are lower than that in the dry season. Furthermore, Sukristiyonubowo (2007) and Uexkull (1970) reported that nutrient concentrations in high yielding varieties from 1.50 to 1.59% N, 0.19 to 0.32% P and 0.30 to 0.37% K are found in rice grains and from 1.05 to 1.28% N, 0.09 to 0.14% P and 1.78 to 2.47% K are observed in rice straw. Depending on nutrient inputs and climate, the total nutrients removed through harvest of high yielding varieties range between 192 and 248 kg N, 24 and 34 kg P, 125 and 198 kg K ha^{-1} $year^{-1}$ (Sukristiyonubowo and Du Liang. 2010; Uexkull, 1970).

Yang *et al.* (2004) observed that incorporation of organic manure in alternating wet and dry water regimes significantly increased N, P, and K uptakes by the rice plants and facilitates translocation of P to rice panicles and grains. Significant improvements in nutrient uptake, rice grains and rice straw yields were also observed in trials combining 12.5 t ha^{-1} of *Gliricidia* leaves manure with inorganic phosphate fertilizer (Kaleeswari and Subramanian, 2004). Another study reported that applications of different sources of organic matter in the rice-wheat cropping system statistically increased total uptake of N, P, and K and rice yield (Singh *et al.* 2001). The objectives of this experiment were to evaluate the amount of nutrients taken out by rice harvest and to develop proper soil fertility management recommendation of newly developed lowland rice fields.

Materials and Methods

Field experiment was carried out in Pati Village; Bulungan District from March to August 2013. Five promising technologies were tested including T0: farmers practices (as control), T1: Package A (NPK at recommendation rate + Dolomite), T2: Package B (NPK at recommendation rate + dolomite + Compost + Smart), T3: Package C (¾ NPK at recommendation rate + Compost + Dolomite + Smart), and T4: Package D (NPK at recommendation rate + Compost + Dolomite + Smart). They were arranged in Randomized Complete Block Design 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, super phosphate-36 (SP-36) and potassium chloride (KCl).

Based on the direct measurement with Soil Test Kits for wetland rice, the recommendation rate was about 200 kg urea, 100 kg SP-36 and 100 kg KCl ha^{-1}, while the farmer practices rate was 100 kg urea and 50 kg SP-36 ha^{-1}. In the treatments of T1, T2 and T3, urea and KCl were applied three times; 50% at planting time, 25% at 21 DAT and at 35 DAT (days after transplanting), while for SP-36 was given two times at planting time 50% and the rest at 21 DAT. For the treatment T4, urea, SP-36 and KCl were given two times namely 50% at planting time and 50% at 21 DAT. Dolomite as much as one ton ha^{-1} and rice straw compost of about two tons ha^{-1} were broadcasted a week before planting. A bio-fertilizer namely Smart was applied as seed treatment with the rate of 10 kg ha^{-1} or 10 kg per 25 kg seeds. The detail treatment is presented in Table 1.

Ciherang rice variety was cultivated as plant indicator. Transplanting was conducted in the end of March 2013 and harvest in the end of July 2013. Twenty-one-day old seedlings were transplanted at about 25 cm x 25 cm plant spacing with about three seedlings per hill. Rice biomass productions including grains, straw, and residues were observed. On a hectare basis, biomass productions were extrapolated from sampling areas of 1m x 1m.

Table 1. The detail treatment of the effect of NPK fertilization, dolomite and compost made of straw in newly opened lowland rice in Pati Village, Bulungan District, North Kalimantan Province

Tabel 1. Perlakuan secara rinci dari pengaruh pemupukan NPK, dolomit dan kompos jerami pada sawah bukaan baru di Dusun Pati, Kabupaten Bulungan, Provinsi Kalimantan Utara

Code	Treatment	Urea	SP-36	KCl	Dolomite	Compost	Smart
		……………………. kg ha^{-1} …………………….					
T0	Farmer practices (as control)	100	50	-	-	-	-
T1	Package A (NPK at recommendation rate+dolomite+compost)	250	100	100	1,000	2,000	-
T2	Package B (NPK at recommendation rate+compost +dolomite+smart)	250	100	100	1,000	2,000	10
T3	Package C (¾ NPK at recommendation rate+compost+dolomite+smart)	187.50	75	75	1,000	2,000	10
T4	Package D (NPK at recommendation rate+compost+dolomite+Smart)	250	100	100	1,000	2,000	10

Note: T1, T2, and T3: NPK at recommendation rate, in which N and K were split three times 50% at planting time, 25% at 21 DAT and the rest were given at 35 DAT

T4: NPK at recommendation rate in which N, P and K were split two times 50% at planting time and 50% at 21 DAT

These sampling units were randomly selected at every plot. Rice plants were manually 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.

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 at 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, while P and K were measured after wet ashing using HClO4 and HNO_3 (Soil Research Institute, 2009).

Nutrient Uptake by rice grain was estimated based on rice grain yield multiplied with nutrient concentration in the grains. Meanwhile, nutrient taken out by rice straw was calculated according to the total rice straw production multiplied by nutrient concentration in the straw. According to Sukristiyonubowo (2007) as the rice residue is remained in the field, therefore it is not considered as nutrient taken out by rice harvest products.

All data were statistically examined by the analysis of variance (ANOVA) and computed using software SPSS program. Means were compared using Duncan Multiple Range Test with a 5% degree of confidence.

Results and Discussion

Biomass production

All treatments improved the rice biomass production, namely rice residues, rice straw and rice grain, but only in the rice grains yield the treatments significantly increased (Table 2). In addition, at the treatment T4 (Package D: NPK at recommendation rate + Compost + Dolomite + Smart) showed the highest rice residues, rice straw, and rice grains productions. In rice grain production, this technology (T4) also increased significant different with other treatments. The biomass rice yields reached were about 1.40 ± 0.08; 3.80 ± 0.13 and 4.15 ± 0.12 t ha^{-1} $season^{-1}$ for rice residues, rice straw, and rice grain, respectively. Compared to T0 (farmers practices), the increase was about 1.77 t ha^{-1} $season^{-1}$ or 74%, 1.57 t ha^{-1} $season^{-1}$ or 71%, 0.15 t ha^{-1} $season^{-1}$ or 74, 78 and 9% for rice grain, rice straw and rice residues, respectively. The farmers mentioned until one year after conversion to wetland rice areas, the rice yield was considered high, reaching 2.0 – 2.5 t ha^{-1}, afterward reduced to 0.5 – 1.5 t ha^{-1}. Therefore, these findings mean that application of NPK with recommended rate plus two tons dolomite ha^{-1} $season^{-1}$ and two tons compost ha^{-1} $season^{-1}$ are essential to elevate and keep rice yield of newly opened wetland rice. This technology makes improving soil fertility resulting in more nutrients available for rice growth and development (Sukristiyonubowo *et al.* 2011).

Nutrient concentrations and removal by harvest products

Compared to the farmer practices (T0), these technologies indicated that the concentrations of N, P, and K in rice grain, and rice straw and rice residues increased (Table 3). The highest concentrations of N, P, and K in rice biomass (rice grain, rice straw and rice residues) were observed at the T2 (Package B: NPK with recommendation rate + Compost + Dolomite + Smart, in which N and K were split three time 50% at planting time, 25% at 21 DAT and the rest given at 35 DAT), indicating more nutrient quantity was taken up by rice grain, rice straw and rice residues.

In addition, these also mean that more nutrients are removed by rice grain and rice straw. The concentrations of N, P, and K in rice grain were 0.99 ± 0.05% N, 0.65 ± 0.03% P, and 0.35 ± 0.05% K and in rice straw 0.77 ± 0.05% N, 0.06 ± 0.01% P, and 2.37 ± 0.21% K.

Table 2. Biomass production of Ciherang variety at different treatments and their enhancement compared to farmer practices cultivated at newly opened wetland rice in Pati Village, Bulungan District, North Kalimantan Province

Tabel 2. Berat brangkasan padi varitas Ciherang pada berbagai perlakuan dan peningkatan hasil dibandingkan dengan cara petani padi yang ditanam pada sawah bukaan baru di Dusun Pati, Kabupaten Bulungan, Provinsi Kalimantan Utara

Treatments	Biomass production			Increasing rice grains yield	
	Rice residue	Rice straw	Rice grains		
	…………………..…………….. t ha^{-1} season^{-1} …………………..……………..				%
T0	1.25 ± 0.21 a	2.13 ± 0.12 a	2.38 ± 0.29 c	-	
T1	1.38 ± 0.31 a	2.94 ± 0.20 a	3.63 ± 0.22 b	1.25	52
T2	1.36 ± 0.23 a	3.45 ± 0.45 a	3.89 ± 0.34 ab	1.51	68
T3	1.38 ± 0.31 a	3.50 ± 0.10 a	3.87 ± 0.27 ab	1.49	61
T4	1.40 ± 0.08 a	3.80 ± 0.13 a	4.15 ± 0.12 a	1.77	74
CV (%)	17.01	14.91	16.01		

Note: The mean values in the same column followed by the same letter are not statistically different

T0: Farmer practices (as control)

T1: Package A (NPK at recommendation rate+compost+dolomite)

T2: Package B (NPK at recommendation rate+compost+dolomite+smart)

T3: Package C (¾ NPK at recommendation rate+compost+dolomite+smart)

T4: Package D (NPK at recommendation rate+compost+dolomite+smart)

Table 3. N, P, and K concentrations and uptake in rice grains, rice straw and rice residues of Ciherang variety planted in newly opened wetland rice in Pati site, Bulungan District, North Kalimantan Province

Tabel 3. Konsentarsi N, P, dan K dan unsur hara yang terkandung di dalam gabah, jerami dan brangkasan padi varitas Ciherang yang ditanam pada sawah bukaan Baru di Dusun Pati, Kabupaten Bulungan, Provinsi Kalimantan Utara

Treatments	Nutrients concentration			Nutrient uptake		
	N	P	K	N	P	K
	……………………. % …………………….			……………… kg ha^{-1} season^{-1} ………………		
Rice grains						
T0	0.83 ± 0.14	0.49 ± 0.08	0.26 ± 0.02	19.63± 2.89 b	11.76 ± 2.02 b	8.49 ± 3.39 c
T1	0.97 ± 0.07	0.59 ± 0.08	0.30 ± 0.06	35.38 ± 3.54 a	20.89 ± 1.54ab	10.75 ± 2.16 b
T2	0.99 ± 0.05	0.65 ± 0.03	0.35 ± 0.02	37.57 ± 3.07 a	25.35 ± 13.93a	13.66 ±1.35 a
T3	0.97 ± 0.18	0.58 ± 0.09	0.31 ± 0.03	37.24 ± 4.73 a	22.42± 4.80 ab	11.98 ± 1.98ab
T4	0.91 ± 0.15	0.58 ± 0.08	0.31 ± 0.06	40.32 ± 4.42 a	24,00 ± 3.86 a	12.77 ± 3.01ab
CV (%)				11.97	29.02	10.26
Rice straw						
T0	0.53 ± 0.04	0.05 ± 0.01	2.19 ± 0.07	11.32 ±1.52 b	1.08 ± 0.25 b	46.61± 1.95 d
T1	0.73 ± 0.18	0.05 ± 0.01	2.33 ± 0,16	21.56 ± 6.33 a	1.88 ± 0.44 a	68.67 ± 8.72 c
T2	0.77 ± 0.05	0.06 ± 0.01	2.37 ± 0,21	26.47± 2.39 a	2.19 ± 0.22 a	82.00 ± 8.62ab
T3	0.67 ± 0.06	0.06 ± 0.02	2.26 ± 0.05	24.97± 3.59 a	1.87 ± 0.58 a	79.22 ± 2.96bc
T4	0.71 ± 0.14	0.05 ± 0.01	2.41 ± 0,06	27.49 ± 4.97 a	1.94 ± 0.41 a	93.08 ±4.31 a
CV (%)				13.46	21.16	8.96
Rice residues						
T0	0.31 ± 0.05	0.15 ± 0.02	1.43 ± 0,04	3.86 ± 0.96 a	1.86 ± 0.21 b	17.87± 3.07 a
T1	0.34 ± 0.06	0.18 ± 0.02	1.51 ± 0.02	5.16 ± 0.18 a	2.46 ± 0.50 ab	20.75 ± 3.26 a
T2	0.38 ± 0.04	0.23 ± 0.02	1.56 ± 0.11	4.89 ± 0.79 a	3.16 ± 0.84 a	21.01 ± 2.17 a
T3	0.31 ± 0.06	0.18 ± 0.03	1.48 ± 0.03	4.44 ± 1.63 a	2.37 ± 0.29 ab	20.44 ± 4.31 a
T4	0.34 ± 0.06	0.18 ± 0,04	1.57 ± 0.03	4.63 ± 0.61 a	2.52 ± 0.71 ab	21.57 ± 4.98 a
CV (%)				22.03	23.11	17.03

Note: The mean values in the same column followed by the same letter are not statistically different

The mean ± sd

The data also suggested that the concentrations of N and P in rice grain were higher than in the rice straw. This presumably because of higher protein contents in rice grain than in rice straw.

In line with the nutrients concentrations, the N, P, and K uptake were also different among the treatments (Table 3). This is due to a significant improvement of rice plant weights during rice growth and their concentrations. These results confirm to the findings reported by Sukristiyonubowo (2007) that N, P and K uptakes increase in relation to the rice growth and the highest N, P and K uptakes are taken place at harvest stage. Compared to T0 (farmers practices), T1 (Package A: NPK at recommendation rate + Dolomite) to T4 (Package D: NPK at recommendation rate + Compost + Dolomite + Smart) treatments showed higher N, P and K uptakes, indicating sufficient nutrients are needed during rice growth and development. The results also confirmed that the highest N, P and K concentration were observed in T2 or Package B (NPK at recommendation rate + Compost + Dolomite + Smart), but for the highest N and P uptakes were in rice grain about 40.32 ± 4.42 kg N ha^{-1} $season^{-1}$ and 25.35 ± 13.93 kg P ha^{-1} $season^{-1}$, and K uptake was in rice straw about 93.08 ± 4.31 K ha^{-1} $season^{-1}$.

As in fact only rice residues were left in the field, the nutrient amounts taken up by rice straw and rice grains reflect the nutrients removal from the field through harvest product. The total removal ranged between (30.96 ± 2.93 and 67.82 ± 8.93 kg N); (12.83 ± 2.15 and 27.53 ± 14.11 kg P), and (55.10 ± 2.92 and 101.84 ± 6.02 kg K) ha^{-1} $season^{-1}$ depending on the treatments (Table 4). Compared to farmer practices (T0), the nutrient removals were significantly different among treatments (Treatment T1 to T4) and the highest nutrient removal was 67.82 ± 8.93 N a + 25.94 ± 4.25 P a and 101.84 ± 6.02 K a t ha^{-1} $season^{-1}$.

Similar ranges have been reported in other studies. Uexkull (1970) found that about 77 kg N, 14 kg P, and 151 kg K ha^{-1} $season^{-1}$ are removed through rice straw and rice grains during wet season by a high yielding variety. These amounts are higher than those removed by an improved local variety. Sanchez and Calderon (1971) also noticed that the N uptake at harvest ranges from 34 to 107 kg N ha^{-1} $season^{-1}$, depending on rice variety. Kemmler (1971) observed that with a yield of 5 t ha^{-1} $season^{-1}$, between 90 and 100 kg N, 20 and 30 kg P, 60 and 80 kg K are removed from the field by high yielding varieties. Sukristiyonubowo (2007) concluded that total nutrient removal through rice grains and rice straw of IR-64 variety vary from 88 to 164 kg N, 8 to 16 kg P, and 104 to 198 kg K ha^{-1} $season^{-1}$ in the WS 2003-04 and from 94 to 165 kg N, 10 to 18 kg P, and 107 to 179 kg K ha^{-1} $season^{-1}$ in the DS 2004.

The nutrients removed through harvest product also meant that about 67 - 150 kg u rea, 65 - 140 kg SP-36 and 105 – 196 kg KCl ha^{-1} $season^{-1}$ were taken out from the field via rice grain and rice straw. Therefore, to avoid nutrient mining and to maintain its inherent soil fertility about 67 to 150 kg urea, 65 to 140 kg SP-36 and 105 to 196 kg KCl ha^{-1} $season^{-1}$ should be added. Like in T2, the urea and KCl were applied three times; 50% at planting time, 25% at 21 DAT and at 35 DAT (days after transplanting), while for SP-36 was given two times at planting time 50% and the rest at 21 DAP. As recently the spirit of Indonesian agriculture practices is applying more organic farming, the application of 100 kg urea, 100 kg SP-36 and 100 kg KCl ha^{-1} $season^{-1}$ plus 2000 kg ha^{-1} $season^{-1}$ compost made from rice straw can also be concerned.

Conclusions

The highest rice biomass production (rice grains, rice straw and rice residues) was found in the Package D (NPK

Table 4. Nutrient removal by harvest product (rice grains + rice straw) of Ciherang rice variety grown in Newly opened wetland rice in Bulungan District, North Kalimantan

Tabel 4. Unsur hara yang terangkut oleh hasil panen (gabah + jerami) padi varitas Ciherang pada sawah bukaan baru di Dusun Pati, Kabupaten Bulungan, Provinsi Kalimantan Utara

Treatments	Nutrient removal		
	N	P	K
	……………..…..……. t ha^{-1} $season^{-1}$ …………..……..…….		
T0	30.96 ± 2.93 c	12.83 ± 2.15 b	55.10 ± 2.92 d
T1	56.94 ± 2.85 b	23.11 ± 2.49 ab	79.42 ± 9.23 c
T2	64.04 ± 5.11 ab	27.54 ± 14.11 a	95.52 ± 7.27 ab
T3	62.21 ± 5.66 ab	23.30 ± 5.43 ab	91.20 ± 3.32 bc
T4	67.82 ± 8.93 a	25.94 ± 4.25 a	101.84 ± 6.02 a
CV (%)	9.28	28.85	7.77

Note: The mean values in the same column followed by the same letter are not statistically different at recommendation rate + Compost + Dolomite + Smart) with application rates of 250 kg urea, 100 kg SP-30, 100 kg KCl, 1000 kg compost and 1o kg bio fertilizer, respectively. Depending on the inputs, total nutrients removal through rice grains and rice straw (mean ± standard deviation) were 30.96 ± 2.93 to 67.82 ± 8.93 kg N, 12.83 ± 2.15 to 27.53 ± 14.11 kg P, and 55.10 ± 2.92 to 101.84 ± 6.02 kg K ha^{-1} $season^{-1}$ or equivalent with 67 to 150 kg urea, 65 to 140 kg SP-36 and 105 to 196 kg KCl ha^{-1} $season^{-1}$. Therefore, to replace the nutrients removed through harvest product and to sustain the soil fertility those amount of nutrients must be replenished every crop season.

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