# Phosphorous and Potassium Balances of Newly Developed Lowland Rice Field in Kleseleon Village, Malaka District, Nusa Tenggara Timur

*Neraca Hara P dan K pada Sawah Bukaan Baru di Dusun Kleseleon Kabupaten Malaka, Nusa Tenggara Timur*

Sukristiyonubowo[1], Sugeng Widodo[2], Prima P.C.[3]

[1] Soil Research Institute, Indonesian Agency for Agricultural Research and Development, Jalan Tentara Pelajar 12, Cimanggu, Bogor 16124, West Java
[2] Balai Pengkajian Teknologi Pertanian Jogyakarta, Indonesian Agency for Agricultural Research and Development, Jalan: Stadion Maguwohardjo 22 Karang Sari, Sleman, D.I. Jogyakarta
[3] Satya Wacana Christian University, Jalan Dipenegoro 54-58 Salatiga 50711, Central Java

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**Abstract**. Development of newly opened lowland rice fields in Indonesia can be both from up land with ustic to hemic moisture regimes and wetland with quick moisture regime. The study was conducted in Ustifluvent soil type of newly developed lowland rice field in Kleseleon village, Malaka District, Nusa Tenggara Timur Province in 2014. Five treatments were tested including T0: farmers practices, T1: NPK at recommendation rate + Rice straw compost, T2: NPK at recommendation rate + Smart + Rice straw compost, T3: ¾ NPK at recommendation rate + Smart + Rice straw compost and T4: NPK at recommendation rate + Smart + Rice straw compost, in which N, P and K application were split two times. The treatments were arranged in randomized complete block design with three replications. The phosphorous and potassium balances were constructed according to the different between nitrogen inputs and nutrient losses. The aims were (1) to evaluate phosphorous and potassium input – output of newly developed lowland rice field and (2) to validate the phosphorous and potassium recommendation according to the phosphorous and potassium balances. The results indicated that there were surplus P and K across the treatments meaning that the amount of SP-36 and KCl were more than enough to replace P and K removed by harvest product. The recommended P and K should be kept to at least 100 kg SP-36 and 100 kg KCl with added compost at least 3 tons $ha^{-1}$ $season^{-1}$.

***Abstrak.*** *Pengembangan sawah bukaan baru di Indonesia dapat berasal dari lahan kering dengan kelembaban tanah ustik sampai hemic dan lahan basah dengan kelembaban tanah cepat. Penelitian dilakukan pada tanah ustifluvent dengan kelembaban ustik dari sawah bukaan baru di Dusun Kleseleon, Kabupaten Malaka, Nusa Tenggara Timur pada tahun 2014. Jenis. Lima teknologi diuji sebagai peralukan: T0: Praktek Petani, T1: NPK dengan dosis rekomendasi + Kompos Jerami Padi, T2: NPK denagn dosis rekomendasi + Smart + Kompos Jerami Padi, T3: ¾ NPK dengan dosis rekomendasi + Smart + Kompos Jerami Padi dan T4: NPK dengan dosis rekomendasi + Smart + Kompos Jerami Padi, dimana N, P and K diberikan dua kali. Perlakuan tersebut diatur dengan Rancangan Acak Kelompok yang diulang tiga kali Penelitian bertujuan (1) mengevaluasi unsur hara P dan K yang masuk dan yang keluar pada sawah bukaan baru, (2) memvalidasi rekomendasi pemupukan P dan K berdasarkan keseimbangan haranya. Hasil penelitian memperlihatkan bahwa terjadi surplus P dan K pada pemberian pupuk 100 kg SP-36 and 100 kg KCl* $ha^{-1}$ $musim^{-1}$*, berarti bahwa jumlah SP-36 dan KCl yang diberikan lebih dari cukup untuk menggantikan P dan K yang diangkut oleh hasil panen padi. Rekomendasi pemupukan P dan K sejogyanya dipertahankan paling tidak sebesar 100 kg SP-36 and 100 kg KCl* $ha^{-1}$ $musim^{-1}$ *dengan memberikan pupuk organik dari kompos jerami sebanyak 3 tons* $ha^{-1}$ $musim^{-1}$*.*

## Introduction

The study on nutrient balances of newly developed lowland rice in Indonesia neither simple nor complete nutrient balance is still rare and not well documented. A complete nutrient balances is very complicated. It is reported that most assessments are partial analysis of these in- and output data (Miller *et al*. 1976. Smaling *et al*. 1993; Drechsel *et al*. 2001; Wijnhoud *et al*. 2003). Therefore, it is urgent to assess nutrient complete balance as a basis to improve fertilizer recommendation. In addition, quantification of nutrient inputs and outputs is also important for agronomical, economical and environmental analyses.

Nutrient balances can be defined as the differences between nutrient gains and losses. A nutrient coming from fertilizers, returned crop residues, irrigation, rainfall, as well as biological nitrogen fixation is grouped as nutrient input (Sukristiyonubowo *et al*. 2012; Sukristiyonubowo *et al*. 2011; Sukristiyonubowo *et al*. 2010; Sukristiyonubowo 2007; Wijnhoud *et al*. 2003; Lefroy and Konboon. 1999 and Smaling *et al*. 1993). According to (Sukristiyonubowo *et al*. 2012; Sukristiyonubowo *et al*. 2011;

*Corresponding author : Email sukristionuboworicky@yahoo.com

Sukristiyonubowo *et al*. 2010; Sukristiyonubowon 2007; Uexkul 1989) nutrient outputs include removal through harvested biomass (all nutrients), erosion (all nutrients), leaching (mainly nitrate, potassium, calcium and magnesium), fixation (mainly phosphate), and volatilization (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 crop production do not reach its potential yields and finally reduces.

For all agriculture commodity in dry land and wet land crops, nutrient balances can be developed at different scales and purposes, including (a) plot, (b) field, farm or catchment, (c) district, province, and (d) country scale (Sukristiyonubowo *et al*. 2012; Sukristiyonubowo *et al*. 2011; Sukristiyonubowo *et al*. 2010; Sukristiyonubowo 2007; Bationo *et al*. 1998; Hashim *et al*. 1998; Van den Bosch *et al*. 1998a; Van den Bosch *et al*. 1998b; Syers *et al*. 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*. 2012; Sukristiyonubowo 2007; Nkonya 2005; Sheldrick 2003; Harris 1998, Van den Bosch. *et al*. 1998a, Van den Bosch *et al*. 1998b).

The study were aimed (a) to evaluate phosphorous and potassium input – output of newly opened wetland rice under different treatments and (b) to validate the P and K recommended application rates. It was hypothesized that proper P and K fertilizer applications rate based on P and K studies lead to optimal rice yield.

## Metholodology

Field experiment on phosphorous and potassium balances of newly developed lowland rice was conducted in Kleseleon Village, Malaka District, Nusa Tenggara Timur Province, in 2014. Soil type was ustifluvent with ustic to hemic soil moisture regime. The site was relatively flat and developed in 2011. Five promising treatments were tested namely T0: farmers practices (as control), T1: NPK with recommendation rate + Rice Straw Compost, T2: NPK with recommendation rate + Smart + Rice Straw Compost , T3: ¾ NPK with recommendation rate + Smart + Rice Straw Compost, and T4: NPK with recommendation rate + Smart + Rice Straw Compost, in which N, P and K were split two times: 50 % was given at planting time and 50 % was added at 21 day after transplanting. These treatments were constructed according to the fact that soil fertility status was classified as low with bases soil pH about 8.02 to 8.20, low soil organic carbon, and farmers do not apply proper P and K fertilizers or the farmers do not apply K fertilizer. The treatments were arranged in 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 about 100 cm. NPK fertilizer used originated from single fertilizer namely urea, SP-36 (Super Phosphate) and KCl (Potassium Chloride). Based on the direct measurement with Soil Test Kits, the recommendation rate was determined about 250 kg urea, 100 kg SP-36 and 100 kg KCl $ha^{-1}$ $season^{-1}$, while the common farmer practices rate was 100 kg urea and 50 kg SP-36 $ha^{-1}$ $season^{-1}$. The urea and KCl were split three times namely 50% at planting time, 25 % at 21 DAT (days after transplanting) and the last 25 % was given at 35 DAT. Rice straw compost of about three tons $ha^{-1}$ were broadcasted a week before planting. Only in treatment T4, N, P and K fertilizers were applied two times: 50 % at planting time and 50 % was given at 21 DAT. In the farmer practices, N was split two time, 50 % at planting time and 50 % at 21 DAT, while for P was given one time at planting time. A week before broadcasting the compost, one kg composite straw compost were taken and analysed for its chemical contents. Bio fertiliser namely Smart was applied as seed treatment with the rate of 10 kg $ha^{-1}$ or 10 kg Smart for 25 kg seeds. The detail treatments are presented in Table1.

Ciherang rice variety was cultivated as plant indicator. Transplanting was carried out in the beginning of March 2014 and harvest in the end of June 2014. Twenty-one-day old seedlings were transplanted at about 25 cm x 25 cm cropping distance with about three seedlings per hill.

Rice biomass production including grains, straw, and residues were measured at harvest. When water content in rice grains were 16 %, the rice plants was harvested, and for measurement the constant weight of rice grains yield the water content of 14 % was used. Sampling units (1m x 1 m plot), were randomly selected at every plot. Rice plants were manually cut about 15 to 20 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 residues were immediately weighed at harvest at each sampling unit. In input-output analysis, rice residue was not considered as an input, as it is always remained in the field.

Phosphorous and potassium inputs were the sum of P and K coming from mineral fertilizers (IN-1), rice straw

Table 1. The detail treatments of NPK fertilization, bio fertilizer and rice straw compost under this study

*Tabel 1. Perlakuan secara rinci dari pemupukan NPK, biofertilizer dan kompos jerami pada percobaan ini.*

| Code | Treatment | Urea | SP-36 | KCl | Smart/ Biofertiliser | Straw Compost |
|---|---|---|---|---|---|---|
| | | ....................................kg ha$^{-1}$ | ................................ | | | |
| T0 | Farmer Practices (as control) | 100 | 50 | - | - | - |
| T1 | NPK with recommendation rate + Rice Straw Compost | 250 | 100 | 100 | - | 3000 |
| T2 | NPK with recommendation rate + Smart + Rice Straw Compost | 250 | 100 | 100 | 10 | 2000 |
| T3 | ¾ NPK with recommendation rate + Smart + Rice Straw Compost | 187.50 | 75 | 75 | 10 | 2000 |
| T4 | NPK with recommendation rate + Smart + Compost, in which N, P and K were split two times: 50 % were given at planting time and 50 % was added at 21 day after planting | 250 | 100 | 100 | 10 | 2000 |

compost (IN-2), irrigation (IN-3), and precipitation (IN-4). Outputs were sum of phosphorous and potassium removed by rice grains (OUT-1) and rice straw (OUT-2). To quantify phosphorous and potassium gains, data included concentrations of P and K in SP-36 and KCl, rate of SP-36 and KCl, amount of P and K in compost, irrigation water supply, P and K concentrations in irrigation waters and in rainfall were collected. The output parameters were rice grain yields, rice straw production, P and K 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 P and K in SP-36 and KCl and compost, respectively. IN-3 was estimated according to water input and nutrients content in irrigation water. Water input was the different between incoming water and outgoing water. Incoming water was calculated by mean of water discharge multiplied by time the inlet is open and close the inlet and outlet during rice life cycle, mainly from land soaking to repining stage. As the P and K concentrations from the outlet were not measured, thus the contribution of phosphorous and potassium from irrigation water was predicted based on water input multiplied by the P and K contents in incoming water, respectively. In this experiment, the pounding water layer was maintained about three cm. The water discharge was measured using Floating method (WMO. 1984). IN-4 was estimated by multiplying rainfall volume with phosphorous and potassium concentrations in the rain water. In a hectare basis, it was counted as follow (Sukristiyonubowo. 2007; WMO. 1984).

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

Where:

- IN-4 is P or K input of rainfall water in kg P and K ha$^{-1}$ season$^{-1}$
- A is rainfall in mm
- 10000 is conversion of ha to m$^2$
- 0.80 is correction factor, as not all rain water goes into the soil
- B is P and K concentrations in rainfall water in mg l$^{-1}$ , respectively
- 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 Malaka were considered. Rain waters were sampled once during rice growth and development 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 (Soil Research Institute 2009).

Phosphorous and potassium losses can be through harvested product (rice grain and rice straw). As all rice grains are transported out of plots, OUT-1 was estimated based on rice grain yield multiplied with P and K concentrations in the grains, respectively. OUT-2 was calculated according to the total rice straw production multiplied with P and K concentrations in the straw, respectively. Rice straw was considered as output because all rice straw was taken out from the field for making compost and the compost is applied for coming planting season.

For the laboratory analyses, rice plants from every plot with the best tiller number from the five teen samples of plant height (vegetative growth) were chosen. 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 the 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. P and K were measured after wet ashing using $HClO_4$ and $HNO_3$ (Soil Research Institute 2009).

## Results and Discussion

### Phosphorous and Potassium Inputs

The P and K inputs originated from application of SP-36 and KCl (IN-1), rice straw compost (IN-2), irrigation water (IN-3) and rainfall water (IN-4) and their P and K contribution are presented in Tables 2, 3 and 4. The IN-1 (contribution of mineral fertilizer) was about +8.00 for farmer practices and + 16.00 kg P ha$^{-1}$ season$^{-1}$ for recommendation rates (Table 2), while for potassium was about + 50.70 kg K ha$^{-1}$ season$^{-1}$ for recommendation rate (Table 2). Therefore, it can be said that the higher the dosage of SP-36 and KCl fertilizers, the higher their contribution to the phosphorous and potassium inputs (Table 2).

The IN-2 was about 3.20 to 4.80 kg P ha$^{-1}$ season$^{-1}$, from the mean of phosphorous content in rice straw compost of 0.09 %, 0.11 % and 0.27 % P, while for K was about 55.80 to 83.70 kg K ha$^{-1}$ season$^{-1}$, from the average of K consentrations of 2.90 %, 2.62 % and 2.85 % K (Table 2). Hence, besides the application rate of compost, the nutrient concentration in compost influenced the contribution. It can also be concluded that application of two and three tons rice straw compost ha$^{-1}$ season$^{-1}$ was higher than application of 100 kg KCl ha$^{-1}$ season$^{-1}$, the KCl recommendation rate.

Phosphorous and potassium contribution inputs from irrigation water (IN-3) were about 0.15 kg P ha$^{-1}$ season$^{-1}$ equivalent to about 0.9 kg SP-36 ha$^{-1}$ season$^{-1}$, meanwhile for potassium was about 11.26 kg K ha$^{-1}$ season$^{-1}$ equivalent to about 22.52 kg KCl ha$^{-1}$ season$^{-1}$ (Table 3), which was considered high, almost one fourth of potassium fertilizer recommended rate.

The input from rain water was about 0.38 kg P, equal to 2.40 kg SP-36 and for potassium was about 0.77 kg K equal to 3.00 kg KCl ha$^{-1}$ season$^{-1}$ (Table 4), which were considered insignificant. Similar results were found in terraced paddy field system in Semarang District of about 2.6 kg P and 6.1 kg K ha$^{-1}$ season$^{-1}$ (Sukristiyonubowo. 2007).

Table 2. The contribution of inorganic fertilizer (IN-1) and straw compost (IN-2) to P and K inputs.

*Tabel 2. Sumbangan dari pupuk mineral (IN-1) dan kompos jerami (IN-2) terhadap P dan K yang masuk.*

| Treatment | Rate of Fertilizer and Compost | | | contribution to P | | Contribution to K | |
|---|---|---|---|---|---|---|---|
| | SP-36 | KCl (kg ha$^{-1}$season$^{-1}$) | Compost | IN-1 (kg P ha$^{-1}$season$^{-1}$) | IN-2 | IN-1 (kg K ha$^{-1}$season$^{-1}$) | IN-2 |
| T0 | 50 | - | - | 8.00 | - | - | - |
| T1 | 100 | 100 | 3.000 | 16.00 | 4.80 | 50.70 | 83.70 |
| T2 | 100 | 100 | 2.000 | 16.00 | 3.20 | 50.70 | 55.80 |
| T3 | 100 | 100 | 2.000 | 16.00 | 3.20 | 50.70 | 55.80 |
| T4 | 100 | 100 | 2000 | 16.00 | 3.20 | 50.70 | 55.80 |

Note: IN-1: P or K input of mineral fertilizer
IN-2: P or K input of compost

Table 3. The contribution of irrigation water (IN-3) to phosphorous and potassium inputs.

*Tabel 3. Sumbangan air irigasi (IN-3) terhadap input P dan K..*

| Treatment | Water input, P and K concentrations | | | Contribution to input | |
|---|---|---|---|---|---|
| | Water input | $PO4^{3-}$ Concentr | K Concentr | IN-3 | IN-3 |
| | (L) | ( mg l$^{-1}$) | ( mg l$^{-1}$) | (kg P ha$^{-1}$season$^{-1}$) | (kg K ha$^{-1}$season$^{-1}$) |
| T0-T4 | 15 x $10^6$ | 0.03 | 0.76 | 0.15 | 11.26 |

Note: IN-3: P or K input of irrigation water

Table 4. The contribution of rain water (IN-4) to phosphorous and potassium inputs.

*Tabel 4. Sumbangan dari air hujan terhadap input P dan K .*

| Treatment | Rainfall, P and K concentrations | | | Contribution to input | |
|---|---|---|---|---|---|
| | Rainfall | P Concen. | K Concen. | IN-4 | IN-4 |
| | (mm) | (mg $PO_4$ $l^{-1}$) | (mg K $l^{-1}$) | (kg P $ha^{-1}$ $season^{-1}$) | (kg K $ha^{-1}$ $season^{-1}$) |
| T0-T4 | 1200 | 0.04 | 0.08 | 0.38 | 0.77 |

Note: IN-4: P or KInput of rain water

**Phosphorous and Potassium Losses**

Phosphorous and potassium losses were estimated from rice grain (OUT-1) and rice straw (OUT-2) taken out from the plots. The P and K loss are presented in Table 5 and 6. P taken away by rice grains ranged between 8.69 and 16.90 kg P $ha^{-1}$ $season^{-1}$ depending on the rice grains production. P removed by rice straw varied from 2.48 to 3.57 kg P $ha^{-1}$ $season^{-1}$. The highest P removed by rice grains was shown by T1 and by rice straw was by T3. However, the total P taken away by harvest product of about 20.47 kg P $ha^{-1}$ $season^{-1}$ was shown by T3 because of the highest rice grains yield and rice straw of this treatment. Therefore, it can be said that increasing rice harvest product remove more nutrients (phosphorous).

Potassium removed by rice grain ranged between 15.46 and 34.02 kg K $ha^{-1}$ $season^{-1}$ depending on the rice grains production. K removed by rice straw varied from 45.63 to 81.20 kg K $ha^{-1}$ $season^{-1}$ (Tabel 6) The highest K removed by rice grains was shown by T1 as well as rice straw .

Table 5. Rice biomass production including rice grain and rice straw of Ciherang variety and total P loss from rice grains (OUT-1) and rice straw (OUT-2)

*Tabel 5. Berat brangkasan padi (gabah dan jerami) varitas Ciherang terhadap P yang hilang dari hasil gabah (OUT-1) dan jerami (Out-2*

| Treatments | Biomass Production | | P concentration | | P loss | | Total P loss |
|---|---|---|---|---|---|---|---|
| | Rice Grain | Rice Straw | Rice Grain | Rice Straw | OUT-1 | OUT-2 | |
| | (t $ha^{-1}$ season-$^{1}$) | | (%) | | (kg P $ha^{-1}$ $season^{-1}$) | | |
| T0 | 3.22 a | 2.48 a | 0.27 | 0.10 | 8.69 | 2.48 | 11.17 |
| T1 | 5.67 b | 3.50 ab | 0.29 | 0.09 | 16.44 | 3.15 | 19.59 |
| T2 | 5.27 b | 3.37 ab | 0.29 | 0.08 | 15.28 | 2.70 | 17.98 |
| T3 | 4.97 b | 3.97 b | 0.34 | 0.09 | 16.90 | 3.57 | 20.47 |
| T4 | 4.88 b | 2.97 a | 0.31 | 0.09 | 15.13 | 2.67 | 17.80 |

Note: OUT-1: P losses by rice grain
OUT-2: P losses by rice straw

Table 6. Rice biomass production including rice grain and rice straw of Ciherang variety and total K loss from rice grain (OUT-1) and rice straw (OUT-2)

*Tabel 6. Berat brangkasan padi (gabah dan jerami) varitas Ciherang terhadap K yang hilang dari gabah (OUT-1) dan jerami (Out-2)pada percobaan Neraca Hara P dan K*

| Treatments | Biomass Production | | K concentration | | K loss | | Total K loss |
|---|---|---|---|---|---|---|---|
| | Rice Grain | Rice Straw | Rice Grain | Rice Straw | OUT-1 | OUT-2 | |
| | ( t $ha^{-1}$ season-$^{1}$) | | (%) | | (kg K $ha^{-1}$ season-$^{1}$) | | |
| T0 | 3.22 a | 2.48 a | 0.48 | 1.84 | 15.46 | 45.63 | 61.09 |
| T1 | 5.67 b | 3.50 ab | 0.60 | 2.32 | 34.02 | 81.20 | 115.22 |
| T2 | 5.27 b | 3.37 ab | 0.55 | 2.05 | 28.98 | 69.09 | 98.07 |
| T3 | 4.97 b | 3.97 b | 0.54 | 1.73 | 26.84 | 68.68 | 95.52 |
| T4 | 4.88 b | 2.97 a | 0.60 | 1.97 | 29.28 | 58.50 | 87.78 |

Note: OUT-1: K losses by rice grain; OUT-2: K losses by rice straw

Thus, total K removed by harvest product of about 115.22 kg K ha$^{-1}$ season$^{-1}$ was shown by T1 because of the highest rice yield and rice straw of this treatment. Therefore, it can also be said that increasing rice harvest product remove more potassium.

**Output-Input Analysis**

The P and K balances of newly opened lowland rice are presented in Tables 7 and 8. In general, the results indicated that inorganic fertilizer (IN-1) contributes considerably to total P and K input in all treatments. The amounts were about 8.00 to16.00 kg P depending on treatment and aboutt 50.70 and kg K ha$^{-1}$ season$^{-1}$, respectively. In the T1 to T4 treatments, IN-1 contributed to about 75 % to 84 % of total input of P (Table 7) and from 35 to 43 % of total K inputs (Table 8).

Compost (IN-2) was also an important nutrient source, contributing about 16 % to 22 % of total P (Table 7) and from 47 to 56 % of total K input (Table 8) depending on the treatment. The IN-2 is more important, when less or no inorganic fertilizers are applied and more organic fertilizer is added. Nutrient supplied by compost was equivalent to 20-25 kg of SP-36 and about 110 - 130 kg KCl. This will be more when the rate of compost application increased.

Although **t**he amounts of potassium coming from irrigation water (IN-3) were smaller compared to the amounts of nutrients originating from inorganic fertilizers (IN-1) and organic fertilizer (IN-2), the contributions of IN-3 to K inputs were still important, covering between 8 % and 93 % of the total K inputs (Table 8).

Table 7. Input-output analysis for phosphorous of newly opened lowland rice field under this experiment

*Tabel 7. Analisis P yang diterima dan yang hilang pada sawah bukaan baru dalam percobaan ini*

| Treatments | P INPUT | | | | | P OUTPUT | | | Balance |
|---|---|---|---|---|---|---|---|---|---|
| | IN-1 | IN-2 | IN-3 | IN-4 | Total P INPUT | OUT-1 | OUT-2 | Total P OUTPUT | |
| | (kg P ha$^{-1}$ season$^{-1}$) | | | | | (kg P ha$^{-1}$ season$^{-1}$) | | | |
| To | +8.00 | - | +0.15 | +0.38 | +8.53 | - 8.69 | - 2.48 | - 11.17 | - 2.64 |
| | 94% | 0% | 2% | 4% | 100% | 78% | 22% | 100% | |
| T1 | +16.00 | +4.80 | +0.15 | +0.38 | + 21.33 | -16.44 | - 3.15 | -19.59 | + 1.74 |
| | 75% | 22% | 1% | 2% | 100% | 84% | 16% | 100% | |
| T2 | +16.00 | +3.20 | +0.15 | +0.38 | +19.73 | - 15.28 | - 2.70 | - 17.98 | + 1.75 |
| | 81% | 16% | 1% | 2% | 100% | 85% | 15% | 100% | |
| T3 | +16.00 | +3.20 | +0.15 | 0.38 | + 19.73 | - 16.90 | - 3.57 | - 20.47 | - 0.97 |
| | 81% | 16% | 1% | 2% | 100% | 82% | 18% | 100% | |
| T4 | +16.00 | +3.20 | +0.15 | +0.38 | + 19.73 | - 15.13 | - 2.67 | -17.80 | + 1.93 |
| | 81% | 16% | 1% | 2% | 100% | 85% | 15% | 100% | |

Table 8. Input-output analysis for potassium of newly opened lowland rice under this experiment.

*Tabel 8. Analisis K yang diterima dan yang hilang pada sawah bukaan baru dalam percobaan ini*

| Treatments | K INPUT | | | | | K OUTPUT | | | Balance |
|---|---|---|---|---|---|---|---|---|---|
| | IN-1 | IN-2 | IN-3 | IN-4 | Total K Input | OUT-1 | OUT-2 | Total K Output | |
| | (kg K ha$^{-1}$ season$^{-1}$) | | | | | (kg K ha$^{-1}$ season$^{-1}$) | | | |
| T0 | - | - | + 11.26<br>93% | + 0.77<br>7% | + 12.03<br>100% | - 15.46<br>25% | - 45.63<br>75% | - 61.09<br>100% | - 49.06 |
| T1 | + 50.70<br>35% | + 83.70<br>56% | + 11.26<br>8% | + 0.77<br>1% | + 146.43<br>100% | -34.02<br>30% | - 81.20<br>70% | - 115.22<br>100% | +31.21 |
| T2 | + 50.70<br>43% | + 55.80<br>47% | + 11.26<br>9% | + 0.77<br>1% | + 118.53<br>100% | - 28.98<br>29% | -69.09<br>71% | - 98.07<br>100% | + 20.46 |
| T3 | + 50.70<br>43% | + 55.80<br>47% | + 11.26<br>9% | +0.77<br>1% | + 118.53<br>100% | - 26.84<br>27% | -68.68<br>73% | - 95.92<br>100% | + 22.61 |
| T4 | + 50.70<br>43% | + 55.80<br>47% | + 11.26<br>9% | + 0.77<br>1% | + 119.50<br>100% | -29.28<br>33% | -58.50<br>67% | -87.78<br>100% | +31.72 |

In general, assessment of P input and output shows a positive balance for all treatments (Table 7). The surplus of P ranged between +1.74 and + 1.93 kg P $ha^{-1}$ $season^{-1}$. The P balances in the T4 was the best surplus compared to the other treatments. Similar to the P balance, K input and Output analysis also indicated positive balances for all treatments (Table 8). The surplus ranged from + 20.46 to + 31.72 kg K $ha^{-1}$ $season^{-1}$, depending on the treatment. For T1 and T4, the K balance were also more positive than the others. These were due to K input from compost were higher than other treatments. To replace K taken out by rice harvest products, therefore, K fertilizer application rate should be sustained to 100 kg KCl $ha^{-1}$ $season^{-1}$ when the rate of compost was not increased. However, when the compost is increased to more 3 tons $ha^{-1}$ $season^{-1}$ as the compost from rice straw is rich in K, then aplication mineral fertilizers rate can be reduced. Regarding the farmers' condition, the last option was more feasible since the rice straw is available in the fields.

The positive P and K balances in all treatments also demonstrated that the application rates of organic and inorganic fertilizers were more than enough to replace P and K removed by rice grains and straw. But when P and K fertilizers application rates were less than 100 kg $ha^{-1}$ $season^{-1}$ or no application P dan K fertilizers were added, the deficit or negative P and K balances occurred. Therefore, it can be said that to obtain better rice production, P and K fertilizers application rate should be maintained as weel as application of compost as P can be longer kept in the soil without damage the environment and will improve soil function As rice straw was a lot in the rice fields and can easily be composted, instead of sustaining inorganic fertilizers 100 kg KCl $ha^{-1}$ $season^{-1}$, to replace K removed by rice harvest product and keep the higher rice grains yield, the organic fertilizer can be increased to more than 3000 kg compost $ha^{-1}$ $season^{-1}$.

## Conclussions

Assessment of P and K inputs and outputs of newly opened lowland rice in Kleseleon, Malaka District indicated that surplus P and K ranged from 1.74 to 1.93 kg P $ha^{-1}$ $season^{-1}$ and +20.48 to 31.72 kg K $ha^{-1}$ $season^{-1}$, meaning that SP-36 and KCl applications rate are more than enough to substitute P and K removed by harvest product. The best rate was shown by NPK at recommended rate + Smart + Rice Straw Compost, in which N, P and K were split two times: 50 % were given at planting time and 50 % was added at 21 day after planting (treatment T4). Therefore, to keep better rice production and to improve soil function, P and K fertilizers application rate as much as 100 kg SP-36 and 100 kg KCl $ha^{-1}$ $season^{-1}$ should be maintained with at least 3000 kg straw compost $ha^{-1}$ $season^{-1}$

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