Efficiency Test of IRRI Fertilizing Recommendations on Rainfed Low Land Rice Field in West Kalimantan

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ABSTRACT

Fertilizing recommendation for lowland rice field in West Kalimantan is still in national scale and tends to be excessive. It is less relevant due to various factors such as the test method competence, the carrying capacity of the land, and the diverse condition of rice field agro-ecosystem. Site-specific nutrient management (SSNM) is an approach for rice fertilizing on paddy plot based on science, history of land fertilization, and nutrient sources surrounding the area which can affect soil fertility level and soil conservation. This study was aimed to examine fertilizing efficiency of N, P, and K and the increased productivity of rice by utilizing software (website) of the IRRI. The study was conducted in farmers fields in two villages, i.e. Anjongan and Pak Bulu, Pontianak Regency, West Kalimantan. The results showed that the SSNM fertilization on rice increased yields by the average of 0.62 t ha⁻¹ (13.47%) per growing season. The efficiency of SSNM fertilization was on the average of 22.05% N, 48.25% P₂O₅, and 31.50% K₂O. The additional profits obtained from the SSNM recommendation was on the average of IDR 1,886,317 per ha per growing season compared to the profits from the FFP (farmer fertilizer practice).

Keywords: Fertilizing efficiency, low land, rice, site specific fertilization

INTRODUCTION

Determination of rice fertilizer dosage recommendations at the national level is considered to be no longer relevant as guidelines for fertilizing rice fields in several regions in Indonesia (Adnyana. 2011). The diversity of soil fertility conditions and site specific environment in some areas, causing the need for balanced fertilization based on site specific conditions and the fertilizer recommendation given is not to be the same in every region (Suryana 2004; Haefele et al. 2010). In some areas of intensification, frequent fertilization lead to the imbalance of nutrients in the soil, damaged to soil properties, environmental pollution and lost of farmer profits (Xu et al. 2009; Pampolino et al. 2012). Excessive fertilization which was not appropriate in dosage, time, and way could cause the plants grow un-optimally, either because of nutrient deficiencies or excessive fertilization (Dobermann and Fairhurst 2000; Buckley and Carney 2013).

Recommended dose of fertilizer for rice is influenced by various factors such as the kind of the test method, the carrying capacity of the land, and the crop needs on various nutrients (Setyorini et al. 2006). There have been many test methods to determine the efficiency of rice fertilization, such as the use of leaf color chart in rice that can save N fertilizer (Wahid 2003). The site specific nutrient management (SSNM) fertilization is a soil nutrient balance-based fertilization technology which uses a rational, efficient fertilization based on the plant needs and according to their variation in time and space (Dobermann 2003; Dobermann et al. 2004; Pasuquin et al. 2014). The SSNM is a computer-based guidelines developed by the International Rice Research Institute (IRRI) in collaboration with the Agency for Agricultural Research and Development (IAARD) through the institutions under its aegis such as the Assessment Institute for Agricultural Technology (AIAT) in every province in Indonesia.
The SSNM is a fertilization technology with a method that requires an answer to a question by using the internet applications that can be accessed through http://webapps.irri.org/nm/id. At the same time, approaches must be relatively simple with minimal characterization or interviewing of farmers for each field in order to ensure rapid, cost-effective delivery of field-specific guidelines to millions of small-scale farmers (Buresh et al. 2007). The answers on some questions that can be easily understood by farmers, such as rice field specifications and history of rice farming management practiced by the farmers which start from land preparation, use of inputs such as seed and fertilizer to harvesting and post-harvest handling, then calculated and can be made rice fertilization recommendation on site specific (Witt and De Datta 1989; Mutert and Fairhurst 2002; Fairhurst et al. 2007). Therefore, the presentation of the SSNM principles needs to be simplified and adjusted with the local way in order to be easily applied by extension workers and farmers and then to be developed on local land condition and rice crop (Janssen et al. 1990).

This SSNM technology needs to be tested in every area in accordance with the nature and diversity of rice fields characteristics and rice farmers characteristics in each region in Indonesia, including in Pontianak Regency, West Kalimantan Province. Pontianak Regency is one of the rice production centers in West Kalimantan, especially in Anjongan Sub-district. Most of the rice fields in Pontianak Regency are in rainfed areas in which the irrigation sources depend on rainfall and in some locations the irrigation sources come from the mountain. The rice yields in those areas were still relatively low in the average of 2-3 tons per hectare.

The farmers habits in those region are transplanting with more than 20 days seedlings, burning rice straw and not returning the residue of the harvested rice straw to the rice fields, applying simple fertilizer based on the ability of farmers to buy fertilizer. Yet for the developed farmers, fertilization rates are in a high dose such as, for urea ranges from 300-400 kg ha⁻¹. This is wasteful and can cause soil contamination problems if it is done continuously. The SSNM is conducted with a hope to be able to increase the fertilization efficiency, profitability and rice yields in rainfed lowland rice for average climatic conditions (Wang et al. 2007; Sapkota et al. 2014). The SSNM-based fertilizer efficiency test in the field can be used to evaluate the fertilizer recommendation for rice fields in various rice producing areas in Indonesia. The SSNM scientific principles for optimally supplying crops with nutrients and local way in order to be easily applied by extension workers and farmers, and then to be developed on local land conditions and rice crops (local specific) (Fageria and Virupax 1999; Timsina et al. 2010).

Farmers, agricultural extension workers, and researchers are involved in the efficiency test of fertilization, in which the determination and implementation of the recommendations are conducted through group discussions. Farmers in the selected fields can work altogether on the work plan that has been agreed. With this efficiency test of fertilization, the recommended fertilizer based on the SSNM principles of IRRI can be analyzed with agronomic perspective. The purpose of this study was to test the fertilization efficiency of rice based on the SSNM recommendation of IRRI and then compared to the practices and habits of FFP in West Kalimantan.

**MATERIALS AND METHODS**

Efficiency test of the SSNM fertilization was conducted on rainfed land owned by farmers in two villages, i.e. Anjongan Village and Pak Bulu Village, Anjongan Sub-district, Pontianak Regency, West Kalimantan Province. This study was carried out in May to December 2012.

Material used in this study were rice seed, fertilizers, i.e. urea, KCl, and NPK compound fertilizers and pesticides, stationery, and gauges crops. Fertilization recommendations were based on the principles of SSNM compared to the FFP recommendations on the same land conditions. This field test was conducted by involving farmers in which the determination and implementation of the recommendations through discussions with farmer groups, extension workers, and researchers from the AIAT.

The study was conducted in rainfed land owned by farmers in the two villages involving 40 farmers which have the land area of 300 m² to 1000 m². The determination of SSNM fertilizer dose was based on the fertilizer dose recommendation of IRRI, which was conducted by interviewing each selected farmer to fill the questionnaire from IRRI website (http://webapps.irri.org/nm/id). Based on the results of SSNM fertilizer recommendations through that internet access, the fertilization period was applied in three times, i.e. in the early period (0-14 days after planting), active tillering, and at the time of primordia (panicle initiation) (Table 1). While the dose of fertilizer by FFP was applied in two periods of fertilization (Table 2).

Each farmer managed both two study plots (SSNM and FFP plots) uniformly. Tillage, rice
varieties, planting, fertilization, pest and disease control, harvesting and post-harvest handling were treated in the same way for both plots (SSNM and FFP). Fertilizers used for SSNM and FFP were bought from the same source.

Determination of crop yields was made when the rice crop physiologically mature. All clumps in the sample plot size of 2 x 5 m were harvested in three plots from the two plot treatments (SSNM and FFP). Then, the weight of dry grain harvest of the SSNM and FFP treatments were measured in kg. Then each dry grain yields were determined at 14% moisture content, calculated by correcting the dry grain yields of SSNM and FFP plots at 14%

| No | Farmer’s name | Location (village) | Field size (m²) | N | P₂O₅ | K₂O | N | P₂O₅ | K₂O | N | P₂O₅ | K₂O | N | P₂O₅ | K₂O |
|----|---------------|-------------------|----------------|---|------|-----|---|------|-----|---|------|-----|---|------|-----|
| 1  | Sukiman       |                   | 462            | 45| 45   | 46  | 0  | 0    | 0   | 0  | 137  | 45  | 45|
| 2  | Supangat      |                   | 360            | 30| 30   | 46  | 0  | 0    | 0   | 0  | 122  | 30  | 30|
| 3  | Poniran       |                   | 320            | 30| 30   | 46  | 0  | 0    | 0   | 0  | 122  | 30  | 30|
| 4  | Rukimin       |                   | 396            | 30| 30   | 46  | 0  | 0    | 0   | 0  | 122  | 30  | 30|
| 5  | Sigit         |                   | 420            | 28| 28   | 43  | 0  | 0    | 0   | 0  | 128  | 28  | 28|
| 6  | Jamal         |                   | 573            | 30| 30   | 46  | 0  | 0    | 0   | 0  | 122  | 30  | 30|
| 7  | Wardoyo       |                   | 490            | 23| 23   | 32  | 0  | 0    | 0   | 0  | 101  | 23  | 23|
| 8  | Helma         |                   | 435            | 28| 28   | 38  | 0  | 0    | 0   | 0  | 105  | 28  | 28|
| 9  | Jais          | Anjongan          | 420            | 60| 60   | 42  | 0  | 0    | 0   | 0  | 146  | 60  | 60|
| 10 | Rebo          |                   | 442            | 30| 30   | 46  | 0  | 0    | 0   | 0  | 122  | 30  | 30|
| 11 | Supit         |                   | 325            | 38| 38   | 38  | 0  | 0    | 0   | 0  | 114  | 38  | 38|
| 12 | Wiji          |                   | 420            | 30| 30   | 42  | 0  | 0    | 0   | 0  | 116  | 30  | 30|
| 13 | Tamiran       |                   | 432            | 38| 38   | 51  | 0  | 0    | 0   | 0  | 143  | 38  | 38|
| 14 | Tarudin       |                   | 420            | 30| 30   | 42  | 0  | 0    | 0   | 0  | 116  | 30  | 30|
| 15 | Panjian       |                   | 456            | 25| 25   | 38  | 0  | 0    | 0   | 0  | 102  | 25  | 25|
| 16 | Muin          |                   | 684            | 28| 28   | 39  | 0  | 0    | 0   | 0  | 106  | 28  | 28|
| 17 | Gondo         |                   | 600            | 19| 19   | 26  | 0  | 0    | 0   | 0  | 72   | 19  | 19|
| 18 | Musriadi      |                   | 308            | 30| 30   | 31  | 0  | 0    | 0   | 0  | 98   | 30  | 30|
| 19 | Tarmuji       |                   | 530            | 30| 30   | 31  | 0  | 0    | 0   | 0  | 98   | 30  | 30|
| 20 | Sumarji       | Pak Bulu          | 539            | 23| 23   | 29  | 0  | 0    | 0   | 0  | 82   | 23  | 23|
moisture content. The yields were converted in t ha\(^{-1}\). Data analysis of rice yields from the SSNM fertilization was compared to the FFP, so it could be seen how much the efficiency of fertilization based on SSNM.

### RESULTS AND DISCUSSION

Fertilization is an effort to increase the availability of nutrients in order to meet the needs of plants. SSNM in aimed at dynamic field-specific

Table 2. Calculation of fertilizer rates for field plot with farmers fertilizer practice treatment.

| No | Farmer's name     | Location (village) | Field size (m\(^2\)) | Calculate the N, P\(_2\)O\(_5\), and K\(_2\)O rates for each date of application | Basal | Second application | Third application | Total |
|----|-------------------|--------------------|----------------------|---------------------------------------------------------------------------------|-------|-------------------|-------------------|-------|
|    |                   |                    |                      |                                                                                 | N P\(_2\)O\(_5\) K\(_2\)O | N P\(_2\)O\(_5\) K\(_2\)O | N P\(_2\)O\(_5\) K\(_2\)O |       |
| 1  | Sukiman           | Anjongan           | 4538                 |                                                                                   | 61 51 15   | 0 0 0            | 46 0 0            | 107 51 15 |
| 2  | Supangat          |                    | 4640                 |                                                                                   | 30 102 30 | 0 0 0            | 92 0 0            | 122 102 30 |
| 3  | Poniran           |                    | 4678                 |                                                                                   | 76 30 30  | 0 0 0            | 46 0 0            | 122 30 30  |
| 4  | Rukimin           |                    | 7010                 |                                                                                   | 61 48 0   | 0 0 0            | 61 0 0            | 123 48 0   |
| 5  | Sigit             |                    | 3580                 |                                                                                   | 29 90 0   | 0 0 0            | 29 0 0            | 58 90 0   |
| 6  | Jamal             |                    | 4316                 |                                                                                   | 92 36 0   | 0 0 0            | 46 0 0            | 138 36 0   |
| 7  | Wardoyo Anjongan  |                    | 4427                 |                                                                                   | 92 72 0   | 0 0 0            | 46 0 0            | 138 72 0   |
| 8  | Helma             |                    | 3565                 |                                                                                   | 19 41 19  | 0 0 0            | 58 0 0            | 76 41 19  |
| 9  | Jais              |                    | 2080                 |                                                                                   | 122 30 30 | 0 0 0            | 92 0 0            | 214 30 30  |
| 10 | Rebo              |                    | 4580                 |                                                                                   | 60 96 60  | 0 0 0            | 0 0 0            | 60 96 60  |
| 11 | Supit             |                    | 5675                 |                                                                                   | 50 110 50 | 0 0 0            | 38 0 0            | 88 110 50 |
| 12 | Wiji              |                    | 2080                 |                                                                                   | 60 96 60  | 0 0 0            | 46 0 0            | 106 96 60 |
| 13 | Tamiran           |                    | 1568                 |                                                                                   | 58 90 0   | 0 0 0            | 58 0 0            | 115 90 0   |
| 14 | Tarudin           |                    | 2068                 |                                                                                   | 122 102 30| 0 0 0            | 92 0 0            | 214 102 30 |
| 15 | Panijan           |                    | 5400                 |                                                                                   | 127 50 50 | 0 0 0            | 77 0 0            | 203 50 50 |
| 16 | Muin              |                    | 1544                 |                                                                                   | 115 90 0  | 0 0 0            | 58 0 0            | 173 90 0   |
| 17 | Gondo             |                    | 3692                 |                                                                                   | 76 64 19  | 0 0 0            | 58 0 0            | 134 64 19 |
| 18 | Musriadi          |                    | 1961                 |                                                                                   | 30 102 30 | 0 0 0            | 92 0 0            | 122 102 30 |
| 19 | Tarmuji           |                    | 1970                 |                                                                                   | 30 102 30 | 0 0 0            | 92 0 0            | 122 102 30 |
| 20 | Sumarji           | Pak Bulu           | 4604                 |                                                                                   | 99 102 30 | 0 0 0            | 46 0 0            | 145 102 30 |
| 21 | Mariana           |                    | 2080                 |                                                                                   | 68 45 45  | 0 0 0            | 23 0 0            | 91 45 45  |
| 22 | Jumiaxi           |                    | 2020                 |                                                                                   | 106 60 60 | 0 0 0            | 46 0 0            | 152 60 60 |
| 23 | Alinus            |                    | 1733                 |                                                                                   | 106 60 60 | 0 0 0            | 46 0 0            | 152 60 60 |
| 24 | Lusiana           |                    | 2480                 |                                                                                   | 63 25 25  | 0 0 0            | 38 0 0            | 102 25 25 |
| 25 | Tuti              |                    | 5550                 |                                                                                   | 38 19 19  | 0 0 0            | 19 0 0            | 57 19 19   |
| 26 | Suparman          |                    | 2580                 |                                                                                   | 127 50 50 | 0 0 0            | 77 0 0            | 203 50 50 |
| 27 | Margareta         |                    | 2040                 |                                                                                   | 76 30 30  | 0 0 0            | 46 0 0            | 122 30 30 |
| 28 | Cica              |                    | 2144                 |                                                                                   | 76 30 30  | 0 0 0            | 46 0 0            | 122 30 30 |
| 29 | Marselina         |                    | 4625                 |                                                                                   | 69 23 23  | 0 0 0            | 46 0 0            | 115 23 23 |
| 30 | Raana             |                    | 4631                 |                                                                                   | 91 45 45  | 0 0 0            | 46 0 0            | 137 45 45 |
| 31 | Viana             |                    | 1480                 |                                                                                   | 95 38 38  | 0 0 0            | 58 0 0            | 153 38 38 |
| 32 | Darem             |                    | 9640                 |                                                                                   | 46 23 23  | 0 0 0            | 23 0 0            | 69 23 23  |
| 33 | Sumiati           |                    | 4570                 |                                                                                   | 38 15 15  | 0 0 0            | 23 0 0            | 61 15 15   |
| 34 | Kristina          |                    | 2140                 |                                                                                   | 152 60 60 | 0 0 0            | 46 0 0            | 198 60 60 |
| 35 | Pendi             |                    | 5640                 |                                                                                   | 63 25 25  | 0 0 0            | 38 0 0            | 102 25 25 |
| 36 | Sumiyati          |                    | 2160                 |                                                                                   | 63 25 25  | 0 0 0            | 38 0 0            | 102 25 25 |
| 37 | Mulia             |                    | 6440                 |                                                                                   | 54 73 21  | 0 0 0            | 33 0 0            | 87 73 21   |
| 38 | Musa              |                    | 4664                 |                                                                                   | 76 30 30  | 0 0 0            | 46 0 0            | 122 30 30 |
| 39 | Una               |                    | 5598                 |                                                                                   | 63 25 25  | 0 0 0            | 38 0 0            | 102 25 25 |
| 40 | Fransiska         |                    | 1580                 |                                                                                   | 95 38 38  | 0 0 0            | 58 0 0            | 153 38 38 |
management of N, P, and K fertilizer to optimize the balance between supply and demand of nutrients. The plant needs for N, P, or K fertilizer are determined from the gap between the supplies of a nutrient from indigenous sources (Wang et al. 2007). Derived from SSNM fertilizer recommendations calculation, the fertilization period was applied in three times with the highest dose of N, P and K were 146, 60 and 60 kg ha\(^{-1}\) respectively (Table 1). At the same time, as the dose of fertilizer by FFP gave in two periods of fertilization with the highest dose of N, P and K were 214, 110 and 60 kg ha\(^{-1}\) (Table 2).

It is quite likely that applying fertilizer N at rates and times to better match the dynamic needs of the rice plant, as practiced with SSNM, can lead to reduced losses of fertilizer N as gases including N\(_2\)O (Pampolino et al. 2007). Fertilizer N applied to submerged rice soils is prone to large losses through mechanisms as ammonia volatilization and nitrification–denitrification (Buresh et al. 2006). Nitrous oxide, a greenhouse gas, is one of the end products of nitrification–denitrification. More effective nutrient management through SSNM can enhance the fertilizer use efficiency leading to more grain yield per unit of fertilizer. This can avoid accumulation of inorganic nutrient in periods when crop demand for added nutrient is low, such as at the end of the rice-growing season.

**Grain Yields**

Dry grain yields of 14% moisture content from 40 farmers in which each farmer fertilizes on plot based on SSNM and FFP in Anjongan Village and Pak Bulu Village are shown in Figure 1.

Figure 1 showed that the fertilization recommendation from IRRI (SSNM) in Anjongan and Pak Bulu Villages had greater dry grain yields (moisture content of 14%) than that of FFP fertilization. The average of dry grain yields (moisture content of 14%) on the SSNM fertilization treatment were 4.93 t ha\(^{-1}\) and 4.42 t ha\(^{-1}\), for Anjongan and Pak Bulu respectively, whereas the FFP were only 4.36 t ha\(^{-1}\) and 3.75 t ha\(^{-1}\) (Figure 2). This showed that the fertilization treatment based on site specific nutrient fertilization (SSNM) was proven to have

![Figure 1](image1.png)  
**Figure 1.** Grain yields from 40 farmers in Anjongan Village (Φ) and Pak Bulu Village (●) based on SSNM (■) and FFP (■■) fertilization recommendation.

![Figure 2](image2.png)  
**Figure 2.** The average of grain yields on SSNM (■) and FFP (□) in Anjongan Village and Pak Bulu Village.
the higher grain yields than the FFP. This agreed with the study of Li et al. (2012) who conducted a research in Jiangsu Province of China to incorporate SSNM into local rice management system in a wheat – rice rotation. They increased rice grain yield by 30% over local FFP, but saved only about 5% N fertilizer. In a more recent study also conducted in Jiangsu Province of China, Xue et al. (2013) developed an improved rice management system combining both SSNM and FFP. Compared with local FFP, SSNM increased rice yield and agronomic N use efficiency by 14.4% and 64.1%, respectively.

Fertilization based on the SSNM recommendation with a lower dose and three periods of fertilization, i.e. in the early planting (0-14 days after planting), in the active tillering of rice plants, and at the time of primordia (panicle initiation), was able to produce more grain yields compared to the FFP fertilization which only applied two periods of fertilization, i.e. in the basis fertilization (basal) and at the time of primordia (panicle initiation).

Fertilization Efficiency

Results of fertilization efficiency on N, P\textsubscript{2}O\textsubscript{5}, and K\textsubscript{2}O on SSNM and FFP fertilization in Anjongan Village and Pak Bulu Village can be seen in Table 3.

Table 3 showed that there was N fertilizer efficiency both in Anjongan Village and Pak Bulu

| Village      | Total of farmers | Grain yield, 14% MC (Mg ha\textsuperscript{-1}) | N (kg ha\textsuperscript{-1}) | P\textsubscript{2}O\textsubscript{5} (kg ha\textsuperscript{-1}) | K\textsubscript{2}O (kg ha\textsuperscript{-1}) | Net benefit (Rp) |
|--------------|------------------|-----------------------------------------------|-------------------|------------------------|-----------------|------------------|
| Anjongan     | 20               | 4.93                                          | 114               | 31                     | 31              | 1.556.277        |
| Pak Bulu     | 20               | 4.42                                          | 81                | 23                     | 18              | 2.216.357        |
| Pontianak District | 40              | 4.67                                          | 98                | 27                     | 24              | 2.599.469        |

Figure 3. The average for efficiency of N, P\textsubscript{2}O\textsubscript{5}, and K\textsubscript{2}O fertilization on the SSNM (◻) and the FFP (◼) in Anjongan Village and Pak Bulu Village.

Figure 4. Additional profit of the SSNM fertilization in Anjongan Village (◻) and Pak Bulu Village (◼).
Village. The SSNM fertilization in those two locations could save N fertilizer at 15 kg ha\(^{-1}\) (11.6%) and 39 kg ha\(^{-1}\) (32.5%), respectively, when compared to FFP fertilization. This agrees with research done by Pasuquin et al. (2014) who found SSNM had a significantly higher N use efficiency compared to the FFP. Average efficiency of N under SSNM was 27 kg kg\(^{-1}\) compared to 19 kg kg\(^{-1}\) in the FFP in the same season, which was an increase of 42% relative to the FFP.

In rice fields Zhejiang Farmer's name Location (village) SSNM FFP Additional net profit for SSNM (IDR)

| No | Total value of rice (IDR) | Total cost of fertilizer used (IDR kg\(^{-1}\)) | Total value of rice (IDR) | Total cost of fertilizer used (IDR kg\(^{-1}\)) | for SSNM (IDR) |
|----|--------------------------|------------------------|--------------------------|------------------------|----------------|
| 1  | 14,867,584               | 1,200,000              | 13,485,597               | 340,000                | 521,987        |
| 2  | 22,283,064               | 940,000                | 19,020,295               | 470,000                | 2,792,769      |
| 3  | 16,539,330               | 940,000                | 14,253,433               | 470,000                | 1,815,897      |
| 4  | 25,059,756               | 940,000                | 22,436,255               | 420,000                | 2,103,501      |
| 5  | 13,414,513               | 944,250                | 12,075,567               | 105,000                | 499,697        |
| 6  | 21,038,111               | 940,000                | 18,501,893               | 315,000                | 2,339,286      |

Table 4. Calculation of profits at the SSNM fertilization recommendation.
China, SSNM increased N fertilizer efficiency more than 50% while fertilizer N was reduced by about 30% (Wang et al. 2007).

Similarly, the efficiency of P$_2$O$_5$ fertilizer was also at 44 kg ha$^{-1}$ (58.7%) in Anjongan Village and 14 kg ha$^{-1}$ (37.8%) in Pak Bulu Village. However, there was no savings on K$_2$O fertilizer of the SSNM fertilization recommendations in Anjongan Village. This was likely due to farmers habits who did not return the residue of harvested rice straw to the rice fields. The residue of harvested rice straw from grain threshing with a thresher was just stacked on the edge of rice fields and burned, so that the source of K was not utilized. Location of irrigation water sources which was far enough from rice fields and drought were also possible causes that made K$_2$O fertilizer on SSNM was higher than the FFP. It did not happen in the locations of Pak Bulu Village that the rice fields were close to irrigation sources and the residues of harvested rice straw were returned to the rice fields, so in that location it could save K$_2$O fertilizer at 16 kg ha$^{-1}$ (47.1%) (Figure 3).

**Additional Net Profit**

The additional net profits of the SSNM fertilization recommendation was towards the FFP fertilization in Anjongan Village and Pak Bulu Village (Figure 4).

Figure 4 showed that the additional net profit in Pak Bulu Village was higher than Anjongan Village. This was due to fact that the N, P$_2$O$_5$, and K$_2$O fertilizations in Pak Bulu Village were more efficient than in the Anjongan Village (Table 3). The additional net profit of the SSNM fertilization recommendation towards the FFP fertilization for Anjongan Village was in the average of IDR 1,556,277 and in Pak Bulu Village was IDR 2,216,357 (Table 4). Pampolino et al. (2007) reported that the added net annual benefit due to use of SSNM was 34 US$ ha$^{-1}$ year$^{-1}$ in Vietnam, 106 US$ ha$^{-1}$ year$^{-1}$ in the Philippines, and 168 US$ ha$^{-1}$ year$^{-1}$ in India. The increased benefit with SSNM was attributed to increased yield rather than reduced costs of inputs.

**CONCLUSIONS**

Site-specific nutrient management (SSNM) fertilization based on the IRRI recommendation was able to increasing rice productivity by the average of additional increase of 0.62 t ha$^{-1}$ (13.47%) per growing season. The SSNM fertilizer recommendation on rice plants was more efficient compared to the farmer’s fertilization practice (FFP), saving N fertilizer in the average of 2.7 t ha$^{-1}$ (22.05%), P$_2$O$_5$ of 2.9 t ha$^{-1}$ (48.22%), and K$_2$O of 0.9 t ha$^{-1}$ (17.89%) per season. The additional net profits from the IRRI fertilization recommendation (SSNM) compared to the FFP in Anjongan Village was about of IDR 1,556,277 and in Pak Bulu Village was IDR 2,216,357. The additional net profit of the SSNM fertilization was about of IDR 1,886,317 per growing season in Pontianak Regency, West Kalimantan Province. It is expected that in each of the Agricultural Extension Center and all farmers in West Kalimantan Province, especially in Pontianak Regency, can refer to the IRRI fertilization recommendation based on the SSNM, because it was proven to be more efficient and profitable. However, it still needs to be furthered research on the SSNM fertilization recommendation in tidal lands.

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**REFERENCES**

Adnyana IM. 2011. Realokasi dan distribusi penggunaan pupuk anorganik berbasis uji tanah pada lahan sawah untuk menunjang gerakan peningkatan produksi beras nasional (P2BN) secara berkelanjutan. The Excellence Research Universitas Udayana 2011. 167-172 (in Indonesian).

Buckley C and P Carney. 2013. The potential to reduce the risk of diffuse pollution from agriculture while improving economic performance at farm level. *Environ Sci Policy* 25: 118-126.

Buresh RJ, KR Reddy, and C van Kessel. 2006. Nitrogen transformations in submerged soils. In: JS Schepers, WR Raun (eds) Nitrogen in Agricultural Soils. ASA, CSSA, and SSSA, Madison, WI.

Buresh RJ, FM Pampolino and C Witt. 2007. Field-specific potassium and phosphorus balances and fertilizer requirements for irrigated rice-based cropping systems. *Plant Soil* 335: 35-64.

Dobermann A and T Fairhurst. 2000. Rice: Nutrient Disorders and Nutrient Management. Potash & Phosphate Institute, Singapore, and IRRI, Manila.

Dobermann A, C Witt, S Abdulrachman, HC Gines, R Nagarajan, TT Son, PS Tan, GH Wang, NV Chien, VTK Thoa, CV Phung, P Stalin, P Muthukhrisn, V Ravi, M Babu, GC Simbahan and MAA Adviento. 2003. Soil fertility and indigenous nutrient supply in irrigated rice domains of Asia. *Agron J* 95: 913-923.
Dobermann A. 2000. Future Intensification of Irrigated Rice Systems. In: JE Sheehy, PE Mitchell, and B Hardy (eds). Redesigning Rice Photosynthesis to Increase Yield. Makati City, Philippines/Amsterdam: International Rice Research Institute/Elsevier pp. 229-247.

Dobermann A, C Witt and D Dawes. 2004. Increasing productivity of intensive rice systems through site-specific nutrient management. Enfield, N.H. (USA) and Los Baños (Philippines): Science Publishers, Inc and International Rice Research Institute (IRRI). 410 p.

Fageria NK and B Virupax. 1999. Nitrogen management for lowland rice production on an Inceptisol. Agricultural Research Service, USDA, NAA, AFSRC, Beaver.

Fairhurst T, C Witt, R Buresh and A Dobermann. 2007. Rice: practical guide to nutrient management (2nd edition). International Rice Research Institute, International Plant Nutrition Institute, and International Potash Institute.

Haefele SM, N Sipaseuth, V Phengsouvanna, K Dounphady and S Vongsouthi. 2010. Agro-economic evaluation of fertilizer recommendations for rainfed lowland rice. Field Crops Res 119: 215-224.

Janssen BH, FCT Guiking, D van der Eijk, EMA Smailing, J Wolf, and H van Reuler. 1990. A system for Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS). Geoderma 46: 299-318.

Li H, L Liu, Z Wang, J Yang and J Zhang. 2012. Agronomic and physiological performance of high-yielding wheat and rice in the lower reaches of Yangtze River of China. Field Crops Res 133: 119-129.

Mutert E and TH Fairhurst. 2002. Developments in rice production in Southeast Asia. Better Crops Inter 15: 1-6.

Pampolino MF, IJ Manguiat, S Ramanathan, HC Gines, PS Tan, TTN Chi, R Rajendran and RJ Buresh. 2007. Environmental impact and economic benefits of site-specific nutrient management (SSNM) in irrigated rice systems. Agric Syst 93: 1-24.

Pampolino MF, C Witt, JM Pasuquin, A Johnston and MJ Fisher. 2012. Development approach and evaluation of the Nutrient Expert software for nutrient management in cereal crops. Comput Electron Agric 88: 103-110.

Pasuquin JM, MF Pampolino, C Wittta, A Dobermann, T Oberthïra, MJ Fisher and K Inubushi. 2014. Closing yield gaps in maize production in Southeast Asia through site-specific nutrient management. Field Crops Res 156: 219-230.

Sapkota TB, K Majumdar, ML Jat, A Kumar, DKBishnoi, AJ McDonald and M Pampolino. 2014. Precision nutrient management in conservation agriculture based wheat production of Northwest India: Profitability, nutrient use efficiency and environmental footprint. Field Crops Res 155: 233-244.

Setyorini D, RW Ladiyani and A Kasno. 2006. Petunjuk Penggunaan uji tanah sawah (paddysoil test kit) versi 1.1. Balai Penelitian Tanah. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian. Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian (In Indonesian).

Suryana A. 2004. Rice research in Indonesia: Present approach and future direction. In: Saeful B and Sunihardi (eds) Food Security and Prosperity Rice. Indonesian Center for Food Crops Research and Development, Indonesian Agency for Agricultural Research and Development, Bogor.

Timsina J, LM Jat and K Majumdar. 2010. Rice-maize systems of South Asia: current status, future prospects and research priorities for nutrient management. Plant Soil 335: 65-82.

Wahid AS. 2003. Increasing the efficiency of nitrogen fertilizer in rice fields and leaf color chart method. Journal of IARD 22: 156-161.

Wang G, QC Zhang, C Witt and RJ Buresh. 2007. Opportunities for yield increases and environmental benefits through site-specific nutrient management in rice systems of Zhejiang province, China. Agric Syst 94: 801-806.

Witt C and SK De Datta. 1989. Rice. In DL Plucknett and HB Sprague (Eds.) Detecting mineral nutrient deficiencies in tropical and temperate crops. West view Press, Inc.

Xue Y, H Duan, L Liu, Z Wang, J Yang, and J Zhang. 2013. An improved crop management increases grain yield and nitrogen and water use efficiency in rice. Crop Sci 53: 271-284.

Xu H, LZ Yang, GM Zhao, JG Jiao, SX Yin and ZP Liu. 2009. Anthropogenic impact on surface water quality in Taihu lake region, China. Pedosphere 19: 765-778.