Preliminary study of the site-specific inorganic fertilization on lowland rice in Bangkalan Madura

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Abstract. A preliminary study of the site-specific inorganic fertilization on lowland rice was carried out in Jambu village, Burneh District Bangkalan Regency East Java Province from March to July 2014. The experiment used a factorial split-plot design, with 5 replications. As the main plot were two varieties of lowland rice namely Inpari 4 and Inpari 10; and as a subplot was fertilization (dose level/inorganic type) based on a. existing practices (250 kg Urea + 300 kg NPK Ponska + 100 kg SP-36) b. PSTK (300 kg Urea + 75 kg SP-36 + 150 kg NPK), c. PC (150 kg Urea + 350 kg Ponska) and d. SSNM (125 kg Urea + 300 kg Ponska). The observations showed that there was no interaction effect between varieties and fertilization to the plant growth and yield. These parameters were affected significantly only by fertilization treatment. The highest weight of plotting yield and harvest yield was obtained in the fertilizer treatment of 453.62 kg/6.25 m2 and 7.26 tons' ha⁻¹. Thus the use of assistive devices, especially the PSTK and SSNM applications were more efficient in the use of inorganic fertilizers with the yields equivalent to the existing practice by the farmers.

1. Introduction

Fertilization is one of the plant maintenance activities that play an important role in crop productivity [1]. However, the reality on the ground showed that farmers often use N fertilizer excessively both from urea, ZA and NPK Posnka that are currently subsidized by the government. The dose can reach 500-700 kg/ha, plus P (SP36) fertilizer between 50-100 kg/ha. Besides, the use of fertilizer doses for each farmer is different even in the same area and commodity. This shows that farmers do not yet know the use of fertilizer doses [2]. Differences in the optimal dose at each location show the importance of applying rational fertilization based on nutrient status in the soil [3].

Fertilization with site-specific nutrient management or application of balanced fertilizers is an effort to provide nutrients needed by plants so that plants grow optimally. The steps in a site-specific fertilization approach are to determine yield levels at a location and season, depending on climate, rice varieties, and crop management; utilize plant nutrients derived from natural sources such as from the soil, overhaul of organic matter, plant residues, manure, and irrigation water; and use chemical fertilizers to fill the gap between the amount of nutrients needed by plants according to the yield level and the nutrients that are naturally available. The benefits and impacts of applying location-specific fertilizers, namely the right dose, the right time, and the type of fertilizer needed are appropriate, the fertilization will be more efficient, high yields, and farmers' incomes increase. Environmental pollution can be avoided, soil fertility is maintained, and rice production is sustainable. In addition, this can reduce waste costs by 15-20% [4,5].
There are many practices and inexpensive methods that can be used in determining soil fertility levels and fertilizer recommendations, especially the nutrient nutrients of N, P, and K. One of them is by using the Paddy Soil Test Kit (PSTK). PSTK is a tool to measure the status of P and K nutrients as well as soil pH that can be done by field counselors or farmers directly in the field. The results of the analysis of soil P and K with PUTS are used as a basis for the preparation of site-specific P and K fertilizer recommendations for lowland rice cultivation [6].

Besides, the International Rice Research Institute (IRRI), in collaboration with several institutions in Asian countries, has since the 1990s developed Site-Specific Nutrient Management (SSNM) technology to determine fertilizer requirements for rice plants [5]. SSNM theoretically helps determine the specific N, P, and K fertilizer requirements. The SSNM considers the availability of nutrients in the soil and the targets to be achieved while ensuring sustainable land fertility [7,8]. In Indonesia, innovation in the form of this application was introduced since 2010 by the Indonesian Agency of Agricultural Research and Development (IAARD) with the name of Site-Specific Nutrient Fertilization (PHSL/SSNF) which can be accessed online. The results of research in Central Java showed that the application of fertilizer recommendations based on the online PHSL program can produce rice production that is comparable (slightly higher) than farmers' fertilizing habits, with a relatively lower fertilization dose [9]. The accuracy and validity of fertilizer recommendations based on PHSL still need to be evaluated and validated on a large scale, and compared with other methods such as soil testing and Permentan 40/2007.

In 2011 the Agricultural Research and Development Agency has also published the Integrated Planting Calendar on a scale of 1: 250,000 which is the development of the Dynamic Planting Calendar. Information that can be accessed is climate prediction (closest planting season), the output of each season distributed via the Website, combined with fertilizer recommendations and fertilizer needs, suitable/potential varieties, seed requirements, areas prone to flooding or drought and areas prone to pest attacks and disease [10]. Fertilization recommendations produced by the Integrated Planting Calendar for the district level are recommended to always be crosschecked with other methods in the field [11]. In this regard, it is necessary to study a site-specific fertilization, based on assistive devices that are more effective and efficient.

2. Methods
The assessment was conducted at rainfed lowland of Jambu village Burneh distrik Bangkalan Regency, from March to July 2014. The experiment used a factorial split-plot design, with 5 replications. As the main plot were two varieties of lowland rice namely Inpari 4 and Inpari 10; and as a subplot was fertilization (inorganic type/dose) as shown in Table 1.

| Code | Treatments                        | Fertilizer dose (kg/ha) | Nutrient content (kg/ha) |
|------|-----------------------------------|-------------------------|--------------------------|
|      |                                   | Urea | SP-36 | NPK Ponska | N    | P    | K    |
| A    | Existing (Farmers practice)       | 250  | 100   | 300       | 160.0 | 81.0 | 45.0 |
| B    | Paddy Soil Test Kit (PSTK)        | 300  | 75    | 150       | 160.5 | 49.5 | 22.5 |
| C    | Planting Calendar -online (PC)    | 150  | 0     | 350       | 121.5 | 52.5 | 52.5 |
| D    | Nutrient Manager for Rice-online (NMR) | 200  | 0     | 300       | 137.0 | 45.0 | 45.0 |

Land tillage was done by using hand tractors that plowed two times, and then raked and smoothed. Organic fertilizer was given before planting about 1 ton / ha that spread on the surface of the ground. Planting was done by legowo row 2:1 with the spacing 40 x 20 x 12.5. The age of young seedlings about 21 days after seedling and 3 - 4 seeds per hole. The dose of fertilizer was assigned by Paddy Soil Test Kit. N fertilizer was applied two times i.e. at 15 days and 21 days after planting. P and K was
applied at 15 days after planting. Weeding was done periodically in accordance with the planting conditions. Pest and disease control was done after monitoring activities.

Variables observed i.e. plants growth that include plant height, number of total tillers and number of productive tillers, and harvest and yield components, and important pest and disease. The data obtained were tabulated and analyzed variance using the general linear model procedure. The significantly difference between treatments was tested further by T–test and DMRT at 5% level. Furthermore, farming analysis was done to determine income and profits of farmers.

3.  Results and discussion

3.1.  Existing condition
The experiment was done on rainfed lowland and inseptisols soil with a clay texture. The result of the soil analysis with the Paddy Soil Test Kit showed that the soil has a low K, and C-organic nutrient content, moderate P with a neutral pH. This location has a dry climate, and rainy season only from late October to June. Climatic condition throughout the study with a daily temperature range between 24-32 °C with a humidity of 65-75%. Rice cultivation was done twice a year with rice-rice cultivated pattern and depend on rainy season. The first planting season in October – February and the second in February/March-May/June.

Rice varieties that often planted by local farmers are Ciherang and IR-64. The soil was cultivated before planting and rarely uses organic fertilizer. Planting seeds was done randomly or planting grain directly by sowing, especially in the first planting season. In the second planting season by transplanting, most of the plants were randomly planted and a small part of the regular planting was a tiled model with a spacing of 20 x 20 cm. The number of seeds per planting hole was 5 to 10 young seeds. Inorganic fertilization with a dose of 250 kg Urea + 300 kg NPK Ponska + 100 kg SP-36. Irrigation only depends on rainfall, so the planting time is often delayed. This condition causes the plants lack water frequently, especially when entering the vegetative phase and seed filling during the second growing season

3.2.  Interaction effect of treatment to plant growth and yield
The results of the statistical analysis showed that there was no interaction effect between the treatment of varieties and fertilization in all variables observed (Table 2). Thus each treatment factor has a free effect on all variables. Therefore, in the description and subsequent discussion will focused on the influence of each factor. There was no significant difference between varieties in all variables observed. A significant difference in influence was only indicated by fertilizer treatments.

Table 2. Analyses of variance of growth and yield parameters of lowland rice plant.

| Source of variance  | Plant height | Total tiller/clump | Length of panicle (cm) | Total grain panicle | Full grain/panicle (%) | Weight of grains/panicle (g) | Weight of 1000 grains (g) | Sampling harvest (kg/6.25 m²) | Yield (ton/ha) |
|---------------------|--------------|--------------------|------------------------|--------------------|------------------------|-----------------------------|-----------------------------|-----------------------------|---------------|
| Main plot (Varieties) | ns           | ns                 | ns                     | ns                 | ns                     | ns                          | ns                          | ns                          | ns            |
| Sub plot (Fertilization) | *           | *                  | ns                     | *                  | *                      | *                           | ns                          | ns                          | ns            |
| Interaction         | ns           | ns                 | ns                     | ns                 | ns                     | ns                          | ns                          | ns                          | ns            |

3.3.  Plant growth
Plant growth performance showed that plant height and total tiller per clump were significantly affected by the treatments (Table 3). The highest plant posture was resulting in SSNM and significantly different from PC. This fact indicated that plant growth especially plant height was dependent on N application dose. The higher the dose of N fertilizer used, the higher plant growth.

The highest number of tillers was obtained in PSTK treatment and only significantly different from PC and was not significantly different from existing and SSNM. This fact indicated that increasing the dose of N fertilizer also affects the number of tillers. The application of those fertilizer doses produced the highest maximum number of tillers and productive tillers [12]. Another study in Sampang showed
that the higher the dose of N fertilizer, the higher plant posture growth and the number of leaves. The best growth was obtained at a dose of 250 kg/ha urea fertilizer [2].

Furthermore, the plant growth in the SSNM and PSTK treatments was not significantly different from the existing. This indicated that even though the dose of fertilizer application was lower than existing, plant growth was not disrupted. Thus the assistive device can be relied upon to determine the site-specific fertilizer dose.

**Table 3.** Effect of varieties and fertilizer to the growth and component yield of lowland rice plant in Bangkalan Madura.

| Source of variance | Plant height | Total productive tiller/clump | Length of panicle (cm) | Total full grain/panicle | % Full grain/panicle | Weight of grains/panicle (g) | Weight of 1000 grains (g) |
|--------------------|-------------|-------------------------------|-----------------------|-------------------------|---------------------|----------------------------|--------------------------|
| **Main plot** (Varieties) |             |                               |                       |                         |                     |                           |                          |
| 1. Inpari 4        | 101.67      | 17.79                         | 22.80                 | 67.06                   | 69.85               | 1.82                       | 18.95                    |
| 2. Inpari 10       | 104.95      | 17.11                         | 23.81                 | 71.23                   | 72.14               | 1.95                       | 19.41                    |
| **Sub plot** (Fertilization method) |             |                               |                       |                         |                     |                           |                          |
| A. Existing        | 103.27 ab   | 17.87 ab                      | 22.48 a               | 67.51 ab                | 67.20 b             | 1.88 ab                    | 19.96 a                  |
| B. PSTK            | 105.05 a    | 18.28 a                       | 23.66 a               | 73.59 a                 | 72.40 ab            | 1.94 a                     | 19.09 a                  |
| C. PC              | 101.83 b    | 16.09 b                       | 23.98 a               | 65.28 b                 | 74.48 a             | 1.77 b                     | 17.75 a                  |
| D. SSNM            | 105.34 a    | 17.52 ab                      | 23.39 a               | 70.18 ab                | 69.90 ab            | 1.91 a                     | 19.99 a                  |

All variables of harvest yield component were significantly affected by the treatments, except the length of the panicle. The highest amount of full-grain was obtained in the PSTK treatment and only significantly different from PC and was not significantly different from SSNM and existing treatment.

The highest percentage of full-grains was shown by PC treatment and significantly different from existing. It seems that the combination of elements N, P and K as in the PC treatment can increase the amount of full-grain pith higher than the other treatments.

The highest grain weight per panicle was obtained in the PSTK treatment and only significantly different from the PC treatment. While the weight per 1000 grains was not affected by treatment. Thus the difference in fertilizer dose does not affect the weight of 1000 grains. This indicates that the high fertilizer dosage as in the existing treatment does not necessarily increase the performance of the yield component.

### 3.4. Plant production

Yield observations (Table 4) show that there are no significant differences between the treatments tested. The highest sample plot yield and total harvest yield were obtained for SSNM and existing treatments. The yield on the SSNM treatment reached 7.18 tons/ha, while in the existing reached 7.26 tons/ha or the yield decrease was only 0.08 tons/ha. This indicates that application of higher doses of fertilizer as usually done by farmers does not necessarily increase the yield of dried unhusked rice. The results of research in Central Java showed that the application of fertilizer recommendations based on SSNM in Tranyu Village was around 63.2% of farmers better (5.31 tons/ha) than the existing (4.79 tons/ha), while in Dukuh Village only around 33.3% of farmers are better (7.84 tons/ha) than existing (7.35 tons/ha) [9]. The rice productivity using SSNM recommendation was higher 20 – 34% than farmer’s practice [13].

### 3.5. Impact to fertilization efficiency

The result of a simple analysis of the costs for purchasing inorganic fertilizers indicates the cost of the fertilizer in existing treatment was higher than assistive device treatments (Table 5). The difference in fertilizer costs ranges from Rp. 285,000 up to Rp. 365,000 or there was efficiency in fertilizing costs from 19.52 % up to 25.00% (Table 5). This fact indicated that the assistive device can reduce the use of inorganic fertilizer, even though the yield is slightly decreased, but does not reduce the profitability of
farming. The similar result was reported that the application of SSNM technology contributed to increase income by IDR3,912,200 in wet season and IDR2,838,700 in dry season [13].

Table 4. Effect of varieties and fertilizer method to yield of lowland rice plant in Bangkalan Madura.

| Source of variance | Sampling harvest (kg/6.25 m²) | Yield (ton/ha) |
|-------------------|-------------------------------|---------------|
| **Main plot (Varieties)** |                               |               |
| 1. Inpari 4        | 4.20                          | 6.72 b        |
| 2. Inpari 10       | 4.60                          | 7.36 a        |
| **Sub plot (Fertilization method)** |                      |               |
| A. Existing        | 4.49 a                        | 7.26 a        |
| B. PSTK            | 4.20 a                        | 6.72 a        |
| C. PC              | 4.36 a                        | 6.99 a        |
| D. SSNM            | 4.53 a                        | 7.18 a        |

3.6. Impact to farming benefit

If seen from the change in revenue due to fertilizer purchase costs, SSNM treatment is still more profitable, even though the value is only 0.05% compared to the existing one (Table 5). These results are in line with research in Central Java that fertilizer recommendations based on online SSNM provide a positive difference in profits from existing 8.27% in Trayu Village and 0.58% in Dukuh Village [9].

Table 5. Analyses of cost efficiency and revenue of some inorganic fertilizer methods on lowland rice in Madura.

| Treatments (inorganic fertilization based on) | Kind of fertilizer | Dose (kg/ha) | Cost of inorganic fertilizer per (Rp/ha) | Total cost of inorganic fertilizer (Rp/ha) | % Cost efficiency of inorganic fertilizer methods to existing | Total yield (kg/ha) | Revenue (Rp/ha) | % Revenue of inorganic fertilizer method to existing | % Revenue of inorganic fertilizer to existing | % Δ treatments revenue to existing |
|---------------------------------------------|--------------------|--------------|------------------------------------------|-------------------------------------------|---------------------------------------------------|-------------------|---------------|-----------------------------------------------|---------------------------------------------|------------------------------------------|
| A (Existing)                                | Urea               | 250          | 500,000                                  | 1,460,000                                 | 0                                                 | 7,263             | 28,325,700    | 28,865,700                                               | 0                                           | 0                                        |
|                                            | SP-36              | 100          | 210,000                                  | 420,000                                   | 0                                                 | 7,263             | 28,325,700    | 28,865,700                                               | 0                                           | 0                                        |
|                                            | NPK                | 300          | 750,000                                  | 2,250,000                                 | 0                                                 | 7,263             | 28,325,700    | 28,865,700                                               | 0                                           | 0                                        |
| B (PSTK)                                   | Urea               | 300          | 600,000                                  | 1,800,000                                 | -25.00                                            | 6,001             | 27,204,000    | 20,100,000                                               | -305,000                                   | -2.50                                   |
|                                            | SP-36              | 75           | 150,000                                  | 450,000                                   | -25.00                                            | 6,001             | 27,204,000    | 20,100,000                                               | -305,000                                   | -2.50                                   |
|                                            | NPK                | 350          | 345,000                                  | 1,195,000                                 | -25.00                                            | 6,001             | 27,204,000    | 20,100,000                                               | -305,000                                   | -2.50                                   |
| C (PC)                                     | Urea               | 150          | 300,000                                  | 900,000                                   | -305,000                                          | 6,727             | 28,235,000    | 25,000,000                                               | -1,605,000                                 | -6.72                                   |
|                                            | SP-36              | 0            | 0                                        | 0                                         | 0                                                 | 6,727             | 28,235,000    | 25,000,000                                               | 0                                           | 0                                        |
|                                            | NPK                | 350          | 875,000                                  | 2,625,000                                 | 0                                                 | 6,727             | 28,235,000    | 25,000,000                                               | 0                                           | 0                                        |
| D (SSNM)                                   | Urea               | 200          | 400,000                                  | 1,150,000                                 | -21.23                                            | 7,187             | 28,092,000    | 26,879,000                                               | 13,600                                     | 0.65                                    |
|                                            | SP-36              | 0            | 0                                        | 0                                         | 0                                                 | 7,187             | 28,092,000    | 26,879,000                                               | 0                                           | 0                                        |
|                                            | NPK                | 300          | 750,000                                  | 2,250,000                                 | 0                                                 | 7,187             | 28,092,000    | 26,879,000                                               | 0                                           | 0                                        |

In general, with the lower dosage level of fertilizer, the yield weight on specific location fertilizer that based on assistive device was as much as existing, more efficient in fertilizer cost and still resulted a positive revenue. This is in line with the opinions of Abdulrahman et al. [14] that there are many benefits and impacts of applying site-specific fertilizers including at the right dose, on time, and at the right type. Fertilization is more efficient, high yields and farmers' incomes increase. Environmental damage also can be avoided, soil fertility is maintained and sustainability in rice production and reduces the cost of purchasing fertilizer [14].

4. Conclusion

Fertilization based on assistive devices, with lower doses does not interfere with plant growth, and the yield was almost the same as existing. Fertilization efficiency reaches 25% compared to exciting and gives a positive profit difference of 0.05%. The assistive devices that have been tried were appropriate to be used as a basis for determining site-specific inorganic fertilization. However, further verification is needed, so that the recommended fertilizer dosage is more accurate.
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