The effectivity of fertilization based on hara index to increase grain rice plants production

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Abstract. Fertilizers addition that is in accordance with the vegetative and generative needs of rice plants, the yield of grain production will be able to increase, to see the nutrients needed by rice plants can be seen with a soil nutrient index. The purpose of this study was to make fertilizer recommendations that appropriate with increased growth and production of the plants based on nutrient index to achieve targeted production. Experimental design research was a factorial completely randomized design with 2 factors and 3 repeats. First factor was given complete fertilizer (urea, SP-36, KCl, and dolomite), consisted of: 0 g/plant; 549.574 g/plant; 824.36 g/plant; 1099.15 g/plant; 1373.94 g/plant. Second factor was soil nutrient index consisted of 0.9 (10% reduced dosage); 1 (standard nutrient index); 1.1 (10% added dosage). The result showed that given fertilizer based on nutrient index significantly effective in grain rice production. The addition of fertilizer in appropriate high dosage of 1373.94 g/plant was able to increase production per plant plot until 5 kg/plot. The conclusion of this research is giving nutrient elements that appropriate with vegetative and generative needs of plants, so that maximum production can be achieved in accordance with the desired production target in one harvest period.

1. Introduction

Production per hectare rice grain in Indonesia averages around 4-5 tons/ha of milled dry grain using standard fertilizer dosages for all regions in Indonesia capable of producing total national rice production of around 35 million tons/year. It is low and still can be increased by 50% to an average of 7.5 tons/ha so that national rice production will reach 47.5 million tons. This can be done by correcting the more suitable fertilizer dosage through fertilizer recommendation based on nutrient index.

Recommendation based on the nutrient index in principle is to increase or reduce soil nutrient supply to plants through balancing soil nutrients and adding fertilizer dosages. Soil nutrient index is the number used as a constant which provided to correct the amount of nutrients that aren’t enough to fulfil the needs of plants, due to variations in soil features, related to its ability to fix nutrients in the soil, so fertilizer dosages are needed greater than the needs of plants. Otherwise, the soil is also able to provide nutrients needed by plants, thus the dosage of fertilizer given is less than the needs of plants, while if the soil does not supply or add nutrients to the need of plants, then the amount of nutrients derived from fertilizers is equal to the amount of nutrients needed by plants.
De Data [1] found that analysis of the nutrient element of rice plants contained in the harvested form of grain and straw was the percentage of nitrogen contained in straw is 0.53%, grain yield is 1.09%, phosphorus content contained in the harvested straw is 0.08%, and grain harvest is 0.20%, while potassium contained in straw harvest is 1.36%, grain harvest is 0.31%, magnesium contained in straw harvest is 0.26%, and grain harvest is 0.11%. With this data, it can be calculated how much the needs of plants to absorb the nutrient.

The low nutrient uptake of fertilizers by plants is largely due to the less optimum process of nutrient supply in soil solutions, i.e. due to low level of soil organic material and incompatibility between the amount of nutrients and plant nutrient needs. Giving complete fertilizer intends to fulfil the needs of rice plants, both in the vegetative and generative period, so that the desired product will be achieved. To see whether the nutrients needed by plants insufficient conditions or not, can be seen by looking at the soil nutrient index so that the effectiveness of fertilization can be achieved.

2. Materials and Methods

2.1 Place and Time
This research would be implemented in the rice fields of Tanjung Mulia village, Tanjung Morawa Sub-district, Deli Serdang Regency, with the altitude of 25 meters above sea level at the coordinates of 3.331810 north latitude and 98.385300 east longitude. It began from October 2018 to February 2019.

2.2 Materials and Tools
The material used in this study was Inpari 32 varieties of rice seed, the basic fertilizers used are Urea fertilizer, Sp-36, KCl and dolomite as fertilizers which would be applied to rice plants, label used as markers of plant plots, and pesticide to control pest and disease.

The tools used were hoes to cultivate research land, plastic rope as a barrier for each experimental plot, scissors for cutting the labels, nets prevented bird pest, knapsack for spray pest, banners used for limit research land, meters to measure the area of land used in research, analytical scale used for weigh research supporting materials, markers or pencils used as a stationary, camera used as documentation tools, and a number of tools used in assisting the research process.

2.3 Research Methods
The research methods used was Factorial Completely Randomized Design with the following treatment:

1. The factor based on giving complete fertilizer (urea, SP-36, KCl, and dolomite)
   - P0 = 0 g/plot (control)
   - P1 = 549.574 g/plot (total of 4 fertilizer dosages)
   - P2 = 824.36 g/plot (total of 4 fertilizer dosages)
   - P3 = 1099.15 g/plot (total of 4 fertilizer dosages)
   - P4 = 1373.94 g/plot (total of 4 fertilizer dosages)

2. The factor based on soil nutrient index
   - B0 = 0.9 (10% reduced dosage)
   - B1 = 1 (100% standard nutrient index)
   - B2 = 1.1 (10% added dosage)

The amount of treatment combinations were 5 x 3 = 15 treatments:

P0B0  P1B0  P2B0  P3B0  P4B0
P0B1  P1B1  P2B1  P3B1  P4B1
P0B2  P1B2  P2B2  P3B2  P4B2
2.4 Conducting Research

2.4.1 Land Preparation. The soil was cleaned from weeds that were on the ground, it cultivated using the hoe by levelling the soil in the rice fields. Furthermore, mapping of 2.4 x 2 meters was carried out on the experimental plot. Then the plot of land was taken with a height of 20 cm, the distance between plots was 20 cm. channels of incoming and outgoing water were arranged in such a way that the irrigation system run well and smoothly with sources of watering coming from irrigation and rain.

2.4.2 Nursery. Before making a nursery, the seeds were soaked first. The seeds that float were removed, the sinking seeds were soaked for 24 hours until it germinated. The nursery media was made in a cup of mineral water, then the seeds were planted into a cup with the amount of one seed per cup.

2.4.3 Fertilization. Fertilization was done only once after tillage. Fertilizer was given according to the production target to be achieved in vegetative and generative growth, and soil nutrient index of 0.9, 1, and 1.1.

2.4.4 Planting. Planting was carried out with a 4:1 jajar legowo planting system with a spacing of 20 x 20 cm. The number of seeds was 3 clumps/planting holes, with seeds age 14 days after seedling.

2.4.5 Plant maintenance.

2.4.5.1 Weeding. Weeding would be done if there were weeds that grow around the rice plant.

2.4.5.2 Pest and Disease Control. Pest control had carried out if there were plants attacked by pests and diseases by using pesticides according to the symptoms of the attack found in the field.

2.4.5.3 Harvesting. Harvesting was done when the plants had shown the criteria for mature harvests with the characteristics of the upper leaves drying out, the grain was fully cooked, hard and yellow. It was done by cutting the stem under the panicle using a sickle on the plant plot.

2.5 Research parameters
Observation of rice plant production was carried out at harvest time. The observation that would do include:

1. Wet grain weight per plot (gram)
   Wet grain weight was calculated by weighing the yield of post-harvested rice grain from clumps of plot plant.

2. Dry grain weight per plot (gram)
   Dry grain weight was calculated by weighing the yield of post-harvested rice grain which had been dried for 1 week from clumps of plot plant.

3. Wet grain weight per sample (gram)
   Wet grain weight per sample was calculated by weighing the yield of post-harvested rice grain from 6 samples per plot plant.

4. Dry grain weight per sample (gram)
   Dry grain weight per sample was calculated by weighing the yield of post-harvested rice grain which had been dried for 1 week from 6 samples per plot plant.

2.6 Technic of Data Analysis
The data was analyzed with quantitative analysis. Quantitative data processing included statistical calculations as well as statistical tests for viewing the effectivity of fertilization based on hara index to increase grain rice plant production. A statistical test used in this research was Duncan Multiple Range Test with the software of Microsoft Excel 2010.
### 3. Result

#### 3.1 Wet Grain Weight Per Plot

Based on the data above, the treatment P4B1 got the highest mean of 5494.51 g/plant while P0B1 had the lowest mean of 3255.15 g/plant. It proves that the administration of fertilizers based on standard nutrient index with higher doses was significantly different compared to those not given fertilizer. The mean yield of wet grain weight per plot could be seen on figure 1.

**Table 1.** The mean yield of wet grain weight for each treatment on rice grain production

| Treatment | Mean (gram) |
|-----------|-------------|
| P0B0      | 3350.93     |
| P0B1      | 3255.15     |
| P0B2      | 3309.97     |
| P1B0      | 4204.48     |
| P1B1      | 3986.10     |
| P1B2      | 3934.68     |
| P2B0      | 4430.65     |
| P2B1      | 4398.29     |
| P2B2      | 4352.50     |
| P3B0      | 4871.54     |
| P3B1      | 4938.10     |
| P3B2      | 4945.71     |
| P4B0      | 5470.51     |
| P4B1      | 5494.51     |
| P4B2      | 5483.95     |

**Figure 1.** The mean yield of wet grain weight per plot
Table 2. Duncan Multiple Range Test for the best dosages of fertilizer to increase rice grain production

| Fertilizer Dosages | Mean     |
|--------------------|----------|
| P0                 | 3305.30eE|
| P1                 | 4041.75 dD|
| P2                 | 4393.81 cC|
| P3                 | 4918.45 bB|
| P4                 | 5482.99 aA|

Based on Duncan Multiple Range Test, the best fertilizer dosage from this study was P4 with a mean of 5482.99 g/plant. It can be compared with P0 which was not given fertilizer, the results could be seen a significant difference so that from the table data above, the maximum dosage of fertilizer could increase rice grain production compared to those not given fertilizer (control).

3.2 Dry Grain Weight Per Plot

The results showed that the dry grain weight in each treatment obtained of P4B0 had the highest mean of 5337.21 g/plant while the lowest was in treatment P0B1 with the mean of 3176.85 g/plant. It could be seen from the data above that there was a significant different between those given the maximum dosage of fertilizer compared to those not given fertilizer (control). Therefore, further testing was needed to see which fertilizer dosage had a large influence on increasing rice grain production. The mean yield of dry grain weight per plot could be seen on Figure 2.

Table 3. The mean yield of dry grain weight for each treatment on rice grain production

| Treatment | Mean (gram) |
|-----------|-------------|
| P0B0      | 3259.95     |
| P0B1      | 3176.85     |
| P0B2      | 3229.97     |
| P1B0      | 4108.41     |
| P1B1      | 3889.14     |
| P1B2      | 3837.51     |
| P2B0      | 4333.16     |
| P2B1      | 4567.29     |
| P2B2      | 4258.20     |
| P3B0      | 4730.60     |
| P3B1      | 4808.04     |
| P3B2      | 4837.80     |
| P4B0      | 5337.21     |
| P4B1      | 5335.57     |
| P4B2      | 5334.08     |
Figure 2. The mean yield of dry grain weight per plot

Table 4. Duncan Multiple Range Test for the best dosages of fertilizer to increase rice grain production

| Fertilizer Dosages | Mean     |
|--------------------|----------|
| P0                 | 3222.26 eE |
| P1                 | 3945.02 dD |
| P2                 | 4386.22 cC |
| P3                 | 4792.14 bB |
| P4                 | 5335.62 aA |

Based on Duncan Multiple Range Test, the results showed that the highest fertilizer dosage (P4) produced grain mean per plant of 5335.62 g/plant while those who were not given fertilizer (control) (P0) only produced grain mean per plant of 3222.26 g/plant. It could be seen from the data above that there was a significant different in each fertilizer treatment proving that the fulfillment of nutrients in rice plants could increase production from rice grain production, thus can produce the desired product.

3.3 Wet Grain Weight Per Sample

From the results of the study in table 5. the highest results in increasing grain production were P4B1 treatment with mean of 85.85 g/plant. Based on the above results, giving relatively large amounts of fertilizer was far better in increasing rice grain production compared to other treatments. The mean yield of wet grain weight per sample could be seen on Figure 3.
Table 5. The mean yield of wet grain weight for each treatment on rice grain production

| Treatment | Mean (gram) |
|-----------|-------------|
| P0B0      | 52.36       |
| P0B1      | 50.86       |
| P0B2      | 51.72       |
| P1B0      | 65.70       |
| P1B1      | 62.28       |
| P1B2      | 61.48       |
| P2B0      | 69.23       |
| P2B1      | 68.72       |
| P2B2      | 68.01       |
| P3B0      | 76.12       |
| P3B1      | 77.16       |
| P3B2      | 77.28       |
| P4B0      | 85.48       |
| P4B1      | 85.85       |
| P4B2      | 85.69       |

Figure 3. The mean yield of wet grain weight per sample

Table 6. Duncan Multiple Range Test for the best dosages of fertilizer to increase rice grain production

| Fertilizer Dosages | Mean       |
|--------------------|------------|
| P0                 | 51.65 dD   |
| P1                 | 63.15 cC   |
| P2                 | 68.65 cBC  |
| P3                 | 76.85 bAB  |
| P4                 | 85.67aA    |

From the results of Duncan Multiple Range Test with the best fertilizer dosage to increase the production of the rice grain, there was a dosage of P4 fertilizer with mean of 85.67 g/plant. This
further proves that the more fulfilled the needs of the vegetative and generative rice itself, the better the production of the grain itself, so that could be determined by the production target that achieved by the fulfillment of nutrients through fertilizer.

3.4 Dry Grain Weight Per Sample
Dry grain weight per sample also produced the highest mean grain rice production in the P4B0 of 83.39 g/plant. It could be seen from the results in table 7. there was no difference from the data among P4B0, P4B1, and P4B2. So it can be concluded that the addition of fertilizer according to the rice harvesting needs could increase the production of rice grain. The mean yield of dry grain weight per sample could be seen on figure 4.

Table 7. The mean yield of dry grain weight for each treatment on rice grain production

| Treatment | Mean (gram) |
|-----------|-------------|
| P0B0      | 50.94       |
| P0B1      | 49.64       |
| P0B2      | 50.47       |
| P1B0      | 64.19       |
| P1B1      | 60.77       |
| P1B2      | 59.96       |
| P2B0      | 67.71       |
| P2B1      | 71.36       |
| P2B2      | 66.53       |
| P3B0      | 73.92       |
| P3B1      | 75.13       |
| P3B2      | 75.59       |
| P4B0      | 83.39       |
| P4B1      | 83.37       |
| P4B2      | 83.35       |

Figure 4. The mean yield of dry grain weight per sample
Table 8. Duncan Multiple Range Test for the best dosages of fertilizer to increase rice grain production

| Fertilizer Dosages | Mean   |
|--------------------|--------|
| P0                 | 50.35 dD |
| P1                 | 61.64 cC |
| P2                 | 68.53 bcBC |
| P3                 | 74.88 bAB |
| P4                 | 83.37 aA |

Duncan Multiple Range Test was used to see the best dosage of fertilizer for increasing rice production. The treatment of P4 fertilizer dosage had the highest mean of 83.37 g/plant which was significantly different from the control or which was not fertilized by the treatment of P0 fertilizer dosage that had low mean of 50.35 g/plant.

4. Discussion

Based on the results of the above study, it could be seen from the results of grain per sample and plot showing very significant different results on the factor P4, compared to the control (P0). This proved that the addition of N, P, K, Ca, and Mg fertilizers simultaneously can increase the production of rice grain until it reached optimal production. This was in accordance with the literature [2] rice plants was needed macronutrients, especially N, P and K. The availability of N, P and K nutrients in the soil was relatively small, so the addition of nutrients through fertilization was needed for optimal production.

The results of research in tables 2, 4, 6, and 8 could be seen that the application of fertilizers with vegetative and generative needs from rice plants was able to increase effectively the level of production of rice grain itself. This was inseparable from the role of N nutrient which was able to play a key role in increasing the production of the rice plant itself, regardless of the nature of N nutrient that was easily washed away and evaporated. With the proper use of urea fertilizer, then could be increased in production from rice grain itself, this was in line with the literature [3], showed that rice plants needed more nutrients to increase yields, where N is one of the key inputs for increasing yields. Yield increase (70-80%) on rice fields could be obtained by the application of N fertilizer.

Increased productivity and yield of rice plants up to 16 tons/ha had been in line with several previous studies that had been carried out. In the previous study, the application of fertilizer based on the weight of straw and the grain in the amount calculated to achieve the predetermined production target obtained yields that were almost the same as the specified production target. This is in line with the research [4], rice was planted in pots and given fertilizer dosages based on the needs of vegetative growth (straw) and generative needs (grain). Complete fertilizer was given based on the calculation of straw weight and grain weight according to the production target. Grain yield was equivalent to 20 tons of grain/ha. The research [5] was conducted in the field with a plot area of 3 m² and the dosage was given for the production target of 10 tons of grain/ha to produce 9.5 tons of grain/ha.

The factor of giving soil nutrient index (B) later was no significant difference in crop production. This occurred because nutrient requirements were available in large quantities in the soil and were exist so that the addition or reduction of the dosage of the fertilizer itself does not significantly affect the production of rice grain itself. This was appropriate with the literature [6] which states that if the soil is not supplied with nutrients derived from fertilizers, the nutrients derived from the soil alone will determine the yield level. If certain nutrients tested in the soil were sufficiently available, then the grain yield would be high or normal, whereas if the amount of available nutrients was low, the grain yield would be low, and that would describe the nutrient status.

The factor of giving complete fertilizer dosage (N, P, K, and Mg) was very effective its role in increasing nutrient availability for rice grain production as shown in tables 2, 4, 6, and 8. Giving complete fertilizer has also considered several aspects of the physical, chemical, and biological properties of the soil itself. So that if given in sufficiently large quantities the nutrients from these
fertilizers can be absorbed properly by plants and increase the production of grain rice without damaging the environment. This is important for aspects of the effectiveness of fertilization so that it can produce a sustainable farming system. This is in line with the literature [7] which states that the effectiveness of fertilizer nutrient utilization was a very prominent part of the intensive rice farming system to produce agronomic effectiveness, increase economic effectiveness and positive impact on the sustainability of environmental functions.

The availability of sufficient water produced high grain weight because it was associated with nutrient absorption. In a state of sufficient water availability, nutrients could be absorbed by plants optimally. Hayati [8] stated that the greater nutrients which could be absorbed provide high growth, which was directly proportional to the increase in photosynthate that results from the process of photosynthesis. Photosynthesis influenced the formation of grain produced.

5. Conclusion
1) Giving complete fertilizer N, P, K, Mg (P) on vegetative growth of rice plants gave a significant effect on increasing rice grain production with the highest mean crop grain in treatment P4 (5335.62 g/plot). 
2) Soil nutrient index (B) in vegetative growth of rice plants did not give a significant effect to increase rice grain production with the highest mean crop was found in soil nutrient index treatment B1 (100% standard nutrient index). 
3) The interaction of complete fertilizer N, P, K, Mg (P) and soil nutrient index (B) in rice grain production gave a significant effect to increase rice grain production in P4B1 interactions (5494.51 g/plot). 
4) If the yield of grain was converted into one hectare of rice fields, then the results achieved in this study would reach 11 tons/ha.

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