Crop productivity and financial feasibility of corn farming with various diverse fertilizer treatments on dry land

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Abstract. In order to improve growth and increase the crop yield, the balanced fertilizer application of Nitrogen (N), Phosphor (P), and Potassium (K) is highly required. The objective research was to study effectiveness of inorganic fertilizer NPK – MgO "Ecobion" on growth and yield of maize. The research was performed on dry land, Dengkol Village, Singosari Subdistrict, Malang Regency. The research applied Randomized Block Design (RBD) with 3 replications. Combined inorganic fertilizing management of NPK – MgO "Ecobion" consisted of 8 levels, such as A = without fertilization, B = 350 kg Urea/ha + 50 kg SP-36 + 450 kg NPK "Phonska"/ha, C = 350 kg Urea/ha + 50 kg SP-36/ha + 200 kg NPK – MgO "Ecobion"/ha, D = 300 kg Urea/ha + 25 kg SP-36/ha + 300 kg NPK – MgO "Ecobion"/ha, E = 250 kg Urea/ha + 400 kg NPK – MgO "Ecobion"/ha, and F = 200 kg Urea/ha + 500 kg NPK – MgO "Ecobion"/ha. Data analysis used ANOVA (Analysis of Variance) and followed by DMRT test 5%. Result of analysis on inorganic nutrient NPK-MgO "Ecobion" including NPK, due to N = 13.91%, P2O5 total = 12.73%, and K2O = 18.54%, so that cumulative contents of N, P and K > 30% that is 45.18% and each content of N, P, and K is higher than 8.0%. The study also revealed that fertilizing management F= 200 kg Urea/ha + 500 kg NPK – MgO "Ecobion"/ha had the best growth (plant height, number of leaf per plant, stem diameter, Leaf Area (LA), Leaf Area Index (LAI)), yield components (diameter of ear, ear length, weight of 100 grains, ear weight per plant, and yield of dry grains) in comparison with other fertilizations and produced the highest dry grains of maize, 8.72 ton/ha, with the gross weight IDR. 33,850,000 and the highest net income (profit) (IDR. 21,657,500; R/C-ratio = 2.77. Fertilizing management F = 200 kg Urea/ha + 500 kg NPK – MgO "Ecobion" showed 189.6% effectiveness (RAE > 100%).

1. Introduction

Maize is the foodstuffs companion of rice in order to promote food diversification, and raw material for feedstuffs industry, in which more than 50% of the feedstuffs use maize, as well as raw material for other manufacturing industries [1,2]. The increasing demand for maize requires increasing production, such as fertilizing management in order to fulfill the nutrients, which are required for the crop growth. Today, the nutrients needed by maize has only fulfilled by applying macronutrients, such as N-inorganic, which is applied continuously without returning the uptake nutrients that have been absorbed by the crop and, of course, it has reduced soil fertility [3] and it has not been recompensed with proportional production increase. However, excessive fertilizer application may not only waste cost, but also disturb nutrients balance in the soil and pollute the environment [4], while less fertilizer application may not be able to provide optimal production. Therefore, in order to increase productivity and quality of the yield, such balanced fertilizing recommendation should be applied, so that comparison of nutrient absolDRtion...
by the plant will be balanced and nutrient accumulation of specific fertilizer will not be found because it has followed the recommended dose of fertilizer in specific location [5].

N, P, and K are essential macronutrients, which are highly required for growth and development of the plant, so that their availability in soil is very important. N, P, and K are required in great amount and stable. However, availability of N, P, and K is limited in the soil and keep decreasing because it has been absorbed by the plant and removed during harvest time, rinsed, evaporated, and floated by erosion, so that the required nutrients could be fulfilled by compound fertilizer application [6,7].

Recommended-complete fertilization, such as NPK, at several sites has faced some obstacles, both socially and economically. If it is recommended to use N, P, and K partially, most of the farmers do not try it and apply more than two fertilizers, and on the other side, the soil requires more than 2 nutrients (for example, N and K). It is also reported that 1 ton maize production requires 15.6 kg N; 2.9 kg P; 3.8 kg K; 0.4 kg Ca; 0.9 kg Mg; and 1.3 kg S [8,9]. The objective of this research are to study effectiveness of inorganic fertilizer of NPK-MgO "Ecobion" on growth and yield of maize and to study effectiveness of inorganic fertilizer of NPK-MgO "Ecobion" economically on maize farm.

2. Methods

2.1. Time and Location
The research was conducted at Dengkol Village, Singosari Subdistrict, Malang Regency. The research was performed during rainy season – I, from November 2016 to March 2017.

2.2. Materials of the Research
Inorganic fertilizers used in the research were Urea, NPK "Phonska" and NPK-MgO "Ecobion" that contain N = 13.91%, P₂O₅ = 12.73, and K₂O = 18.54%. The examination used P-21 hybrid variety.

2.3. Experimental Design
The research was conducted and based on Randomized Block Design (RBD) with 3 treatments and 4 replications (Table 1).

| Treatment | Type and Dose of Fertilizer | Urea (kg/ha) | SP-36 (kg/ha) | NPK "Phonska" (kg/ha) | NPK-MgO "Ecobion" (kg/ha) |
|-----------|----------------------------|--------------|---------------|----------------------|--------------------------|
| A         |                            | 0            | 0             | 0                    | 0                        |
| B         |                            | 350          | 50            | 450                  | 0                        |
| C         |                            | 350          | 50            | 0                    | 200                      |
| D         |                            | 300          | 25            | 0                    | 300                      |
| E         |                            | 250          | 0             | 0                    | 400                      |
| F         |                            | 200          | 0             | 0                    | 500                      |

2.4. Implementation of the Research
For seed preparation, pure and high-qualified maize seeds are the most important requirements in maize breeding, such as P-21 hybrid variety. Viability, at least, 85%, and pure. Location of the research is agroecosystem of dry soil that covers total area ± 0.10 ha. The soil was cultivated using tractor and hoed evenly. Size of the plot is 4.5 m x 6 m. Drainage line, 50 cm width and 25 cm depth, is built between the plots. It is intended to maintain the fertilization treatment and to avoid any mixing of fertilizer solution flow or fertilizer solution infiltration between the plots. Line, 25 cm depth and 30 cm width, is built around the experimental plot. P-21 variety is planted using dibble with spacing 75 cm x 20 cm, 1 seed per hole. Fertilizer used in this study were urea, SP-36, NPK "Phonska", and NPK-MgO "Ecobion" and a third dose is applied on the crop at 14 DAP (day after planting), 28 DAP, and 42 DAP using dibble with spacing 5 cm next to the crop, and then the hole is covered with soil.
2.5. The Measured Variable
Variables measured in this study are as follow: (1) plant height at 21, 35, 49, and 63 DAP, (2) Stem diameter at 21, 35, 49, and 63 DAP, (3) Leaf area at 60 DAP and 90 DAP, (4) Leaf length at 60 DAP and 90 DAP, (5) Weight of ear per plant, (6) weight of 100 grains, (7) Yield of dry grains.

2.6. Analysis
The resulted inorganic fertilizer was tested in laboratory in order to find out the level of N (%), P$_2$O$_5$ (%), K$_2$O (%), water content (%), assays (B, Cu, Mn, Mo, Co, Hg, Pb, Cd, and MgO). The analysis was conducted at Laboratory for Soil Fertility and Plant Nutrition, Department of Soil Science and Land Resources, Faculty of Agriculture, Padjajaran University, Bandung, 2016.

During preliminary research, soil sample was taken to find out status of soil fertility and chemical properties of the soil. Analysis on soil sample pre-experiment include: pH (H$_2$O and KCl), N total (%), P$_2$O$_5$ Olsen (ppm), K-dd (cmol (+)/kg), Cation Exchange Capacity (CEC) (cmol (+)/kg), and soil texture. Analysis was conducted at Laboratory of Soil, Assessment Institute for Agricultural Technology (BPTP) Balitbangtan, East Java, 2016.

Data of agronomy and the results were analyzed statistically using ANOVA (*Analysis of Variance*). In order to study the effect of treatments on parameter of observation, statistical analysis is performed by formulation below:

\[
Y_{ij} = \mu + K_j + \alpha_i + \epsilon_{ij}
\]  
(1)

In which:

\[i = 1, 2, 3, \ldots , p\] (number of treatment)
\[j = 1, 2, 3, \ldots , l\] (number of group)
\[Y_{ij}\] = observational value on experimental unit
\[\mu\] = general median
\[K_j\] = treatment effect of group - j
\[\alpha_i\] = treatment effect of group - i
\[\epsilon_{ij}\] = gallate of the experiment on experimental unit of group-j by treatment at level-i

If any difference is found between treatments, it will be followed by Duncan Multiple Range Test (DMRT) at level 5%. If the treatments, on average, are lower (<) than the test values, it means that both treatments do not have significant influences (insignificantly difference). If the treatments, on average, are higher (>) than the test values, it means that both treatments have significant influences (significantly difference). Result of the intermediate test was presented in superscript sign at the right side of the average tested treatment (Duncan 0.05).

Higher mean of variable is better, so that the lowest value is the worst and the highest value is the best. On the contrary, the lower value of variable is better so that the highest value means the worst and the lowest value means the best. Counting the yield value (Nh) of each variable that derived from multiplication of normal weight (BN) and effectiveness value (Ne). Counting up the yield values of the whole variables, and the best combination will be selected from combined treatments that have the highest yield values (Nh).

Effectiveness of organic fertilizer NPK-MgO"Ecobion" is approached using Relative Agronomic Effectiveness (RAE) method. Each treatment was tested on standard fertilizer (in this experiment is treatment 2). RAE is comparison between the yield increase of using specific fertilizer and the yield increase of using standard fertilizer and multiplied by 100. RAE equation is as follows:

\[
\text{RAE} = \frac{\text{Yield of the tested fertilizer} - \text{control}}{\text{Yield of the standard fertilizer} - \text{control}} \times 100
\]  
(2)

In order to find out properness of a treatment, it requires to perform income analysis and cost efficiency on each treatment. Farming cost is all expenses that are used for farming. Farming cost is divided into two, fixed cost and variable cost. Mathematically, equation to count farming income is presented below:
\[ \pi = Y \cdot P_y - \Sigma X_i \cdot P_{xi} - BTT \]  

(3)

In which:
\[ \pi \] = Income (IDR)
\[ Y \] = Yield of production (kg)
\[ P_y \] = Price for yield of production (IDR)
\[ X_i \] = Factor of Production (I = 1, 2, 3, …, n)
\[ P_{xi} \] = Price for factor of production-I (IDR)
\[ BTT \] = Total fixed cost (IDR)

In order to find out whether the treatment is economically profitable or not, it will be analyzed using ratio or comparison between revenue and cost (revenue cost ratio). Mathematically, it can be formulated as follows:

\[ \frac{R}{C} = \frac{PT}{BT} \]  

(4)

In which:
\[ \frac{R}{C} \] = Revenue cost value
\[ PT \] = Total revenue (IDR)
\[ BT \] = Total cost (IDR)

However, criteria for decision-making are as follow:
- If \( \frac{R}{C} > 1 \), means that the farm is profitable due to revenue is higher than cost.
- If \( \frac{R}{C} < 1 \), means that the farm suffers loss due to revenue is lower than cost.
- If \( \frac{R}{C} = 1 \), means that the farm is balanced due to revenue equals to cost.

3. Results and Discussion

3.1. Characteristic for Location of the Research
At the beginning of the research, soil sample was taken in order to find out soil fertility status and factors that inhibit the plant growth at location of the research. The analysis results for chemical properties of the soil along with the criteria are presented in Table 2. Soil analysis showed that soil fertility on location of the research was acid by pH 5.1. N, P, and K levels are moderate, while Cation Exchange Capacity (CEC) of the soil is low. Optimal availability of P is in neutral pH that ranges 6.5 – 7.0, while pH for optimal availability of K ranges 6.5 – 7.2. Lower pH is not due to Al or Fe activity, but the increase of \( H^+ \) ion, which derived from organic acids, such as oxalate, sulphate, citric, and malic that resulted from organic material decomposition [2,11].

Low pH may affect nutrient availability, which is shown by lower availability of nutrients, such as N and K. Low availability is caused by \( K^+ \) ion, which is released from complex of soil absorbable and will be filled by \( Al^+ \) and \( H^+ \) ions. It creates acid condition by moderate levels of N, P, and K, as well as low Cation Exchange Capacity (CEC) in the soil, so that more nutrients are required by applying NPK fertilizer.

Table 2. Analysis Result on Nutrients Pre-Experiment of Inorganic Fertilizer Application of NPK-MgO "Ecobion” on Maize, Rainy Season-I, 2017, SIngosari-Malang

| No. | Parameter of Testing | Result | Unit | Method | Rate |
|-----|----------------------|--------|------|--------|------|
| 1.  | Water                | 4.23   | %    | Oven 105°C | Low  |
2. pH

|                | Value   | Method                                      | Level |
|----------------|---------|---------------------------------------------|-------|
| - H₂O          | 5.1     | (1:5), electrometry, pH meter               | Low   |
| - KCl          | 4.0     | (1:5), electrometry, pH meter               | Low   |

3. N total *)  

|                | Value   | Method                                      | Level |
|----------------|---------|---------------------------------------------|-------|
|                | 0.21%   | Kjeldahl, Titrimetry                        | Moderate |

4. P₂O₅ *)

|                | Value   | Method                                      | Level |
|----------------|---------|---------------------------------------------|-------|
|                | 38 Ppm  | Olsen, Spectrophotometry                    | Moderate |

5. Kdd (exchangeable) *)  

|                | Value   | Method                                      | Level |
|----------------|---------|---------------------------------------------|-------|
|                | 0.41 me.100g⁻¹ | Percolation NH₄, Acetate 1 M, pH 7, AAS | Moderate |

6. Cation Exchange Capacity (CEC) *)  

|                | Value   | Method                                      | Level |
|----------------|---------|---------------------------------------------|-------|
|                | 11.51 me.100g⁻¹ | Percolation NH₄, Acetate 1 M, pH 7 + NaCl 10% Titrimetry | Low |

Notes: *) = against the sample of dried-oven 105°C

3.2. Plant Growth

3.2.1. Plant Height. Results for analysis of variance showed that fertilization did not effect on plant height at 21 Days After Planting (DAP), but showed significant effect on plant height at 35, 49, and 63 DAP. Results of observation on plant height at 21, 35, 49, and 63 DAP are presented in Table 3.

Results of DMRT test at level 5% showed significant difference among fertilization treatments at 35, 49, and 63 DAP. At 63 DAP, the highest plant was obtained by combination of fertilization treatment, such as 200 kg Urea/ha + 500 kg NPK Ecobion (F) and showed significant difference with other treatments (Table 4). If it was compared with without fertilization as well as higher recommended dose 32.50% dan 9.4%. It was assumed that the increasing height following the application of more dose of inorganic fertilizer, related to the effect of N, which stimulates various physiological activities of the plant, such as in cell division and cell elongation.

Low pH may affect nutrient availability, which is shown by lower availability of nutrients, such as N and K. Low availability is caused by K⁺ ion, which is released from complex of soil absorption and will be filled by Al⁺ and H⁺ ions. It creates acid condition by moderate levels of N, P, and K, as well as low Cation Exchange Capacity (CEC) in the soil, so that more nutrients are required by applying NPK fertilizer.

Table 3. The Effect of Fertilizer NPK-MgO "Ecobion” on Plant Height at 21, 35, 49, and 63 DAP, Rainy Season-I, 2017, Singosari, Malang

| Treatment | Plant Height (cm) |
|-----------|-------------------|
|           | 21 DAP a) | 35 DAP s) | 49 DAP s) | 63 HST s) |
| A         | 21.10 a   | 44.80 a   | 68.30 a   | 150.75 a  |
| B         | 22.60 a   | 55.70 cd  | 97.30 b   | 185.25 d  |
| C         | 22.50 a   | 52.10 b   | 96.95 b   | 176.30 b  |
| D         | 21.60 a   | 55.30 c   | 95.90 b   | 185.30 d  |
| E         | 21.30 a   | 56.35 cd  | 98.05 b   | 180.50 c  |
| F         | 22.70 a   | 58.05 d   | 106.35 c  | 199.75 e  |
| CV        | 14.39     | 5.82      | 4.67      | 2.87      |

Notes : Number followed by the same letter in the same column shows no significant difference at level 5% on DMRT test; ns = not significant; s = significant

Plant height is one of standards to find out fertilization response to vegetative growth. Plant height is measurement that is mostly observed as growth indicator and as parameter to measure environmental effect or the applied treatment because plant height is considered as growth measurement that is easily viewed [27]. When the plant is at 21 DAP with fertilization treatment F = (200 kg Urea/ha + 500 kg NPK-MgO "Ecobion")/ha showed the highest height, 22.70 cm, even though it had no significant
difference with other fertilization treatment. At 35, 49, and 63 DAP, treatment \( F = (200 \text{ kg Urea/ha} + 500 \text{ kg NPK-MgO "Ecobion"})/\text{ha} \) showed significant difference and the highest than other treatments. Plant heights with fertilization application of \( F = (200 \text{ kg Urea/ha} + 500 \text{ kg NPK-MgO "Ecobion"})/\text{ha} \) at 21, 49, and 63 DAP were 58.05 cm, 106.35 cm, and 199.75 cm, respectively. Low fertilization treatment at 35 DAP was treatment A, without fertilization, and B \( (350 \text{ kg Urea/ha} + 50 \text{ kg SP-36/ha} + 450 \text{ kg NPK "Phonska"})/\text{ha} \) resulted 44.80 cm and 52.10 cm. Another study reported that increase dose of fertilizer N 67.5 kg/ha or Urea 150 kg/ha may increase plant height 251.08 cm (13.73%) in comparison with without N fertilizer application, and plant height increases 262.66 cm along with the increases dose of N 135 kg/ha or Urea 300 kg/ha [2,4,12].

3.2.2. Stem Diameter. Results for analysis of variance showed that inorganic fertilizer from Urea, SP-36, and NPK "Phonska", as well NPK-MgO "Ecobion" have significant effect on stem diameter of maize at 21, 35, 49, and 63 DAP. The observation results on stem diameter at 21, 35, 49, and 63 DAP are presented in Table 4.

| Treatment | Stem Diameter (cm) |
|-----------|--------------------|
|           | 21 DAP s\(^{3}\) | 35 DAP s\(^{3}\) | 49 DAP s\(^{3}\) | 63 DAP s\(^{3}\) |
| A         | 0.25 a            | 1.32 a            | 1.64 a            | 1.94 a            |
| B         | 0.31 b            | 1.52 b            | 1.83 b            | 2.42 d            |
| C         | 0.26 ab           | 1.47 b            | 1.80 b            | 2.11 b            |
| D         | 0.22 a            | 1.50 b            | 1.83 b            | 2.13 b            |
| E         | 0.23 a            | 1.40 a            | 1.80 b            | 2.25 c            |
| F         | 0.27 ab           | 1.52 b            | 1.93 c            | 2.46 d            |
| CV        | 5.66              | 10.86             | 7.85              | 4.94              |

Notes: Numbers followed by the same letter in the same column show no significant difference at level 5% on DMRT test; ns = not significant; s = significant

During observation at 63 DAP, among fertilization treatment using NPK-MgO "Ecobion")/ha, treatment \( F = (200 \text{ kg Urea/ha} + 500 \text{ kg NPK-MgO "Ecobion"})/\text{ha} \) along with the application 200 kg Urea/ha (reducing dose of Urea from 350 kg/ha to 200 kg/ha) without application of fertilizer SP-36 and NPK "Phonska" showed the greatest numbers of leaf, 18.9 blades or increase 29.10% in comparison with the application of 200 kg NPK-MgO "Ecobion"/ha along with the application of 350 kg Urea/ha + 50 kg SP-36/ha and increase 29.63% in comparison with the application of 300 kg NPK-MgO "Ecobion"/ha along with the application of 300 kg Urea/ha + 25 kg SP-36/ha, and increase 28.57% in comparison with the application of 400 kg NPK-MgO "Ecobion"/ha along with the application of 250 kg Urea/ha. Besides N, however, P and K are required for growth and stem formation that creates annual ring. Besides that, Phosphor plays important role in biochemical process and protein metabolism on plant [2].

3.2.3. Leaf Area (LA) Per Plant and Leaf Area Index (LAI) of Maize. Results for analysis of variance showed that inorganic fertilizer from Urea, SP-36, and NPK "Phonska" as well as NPK-MgO "Ecobion" have significant effect on Leaf Area per plant at 60 and 90 DAP. Results of observation on number of leaf per plant at 60 and 90 DAP are presented in Table 5.

| Treatment | Leaf Area per Plant (cm\(^{2}\)) s\(^{3}\) |
|-----------|---------------------------------|
|           | 60 DAP                          | 90 DAP                          |
| A         |                                 |                                 |
| B         |                                 |                                 |
| C         |                                 |                                 |
| D         |                                 |                                 |
| E         |                                 |                                 |
| F         |                                 |                                 |
| CV        |                                 |                                 |

Table 5. Effect of Fertilizer NPK-MgO "Ecobion" on Leaf Area (LA) per Plant at 60 DAP and 90 DAP, Rainy Season-I, 2017, Singosari, Malang
Measuring leaf area per plant is affected by number of leaf per plant. The application of inorganic fertilizer NPK-MgO "Ecobion" for about 200 – 500 kg/ha during observation at 60 DAP and 90 DAP has significantly shown increase of leaf area. The application of F = (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha showed the greatest Leaf Area, 5.82 cm² (60 DAP) and 6.36 cm² (90 DAP) even though it did not show significant difference with the treatment D = (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha and D = (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha (90 DAP).

In accordance to previous studies [11,12] leaf is the place where photosynthesis occurs due to it contains chlorophyll, which transforms carbondioxide and water into carbohydrate and oxygen by the assistance of the sun’s rays. And then, the carbohydrate will be used to produce other compounds, which are required to form cell structure of the plant and to support metabolism activities, as well as to be accumulated in specific organ cells. Therefore, leaf area is one of important parameters in growth analysis of plant. Greater leaf area means that the photosynthetic process on leaf will be higher, so that it produces more photosynthates. Concerning with Effectiveness Test on Solid Organic Fertilizer and NPK on growth and production of maize concluded that the application of solid organic fertilizer and NPK have significant effect on leaf area, ear length, ear diameter, production of dry grains and weight of ear.

Results for analysis of variance showed that inorganic fertilizer from Urea, SP-36, and NPK "Phonska", as well as NPK-MgO "Ecobion” have significant effect on Leaf Area Index (LAI) of the maize at 60 and 90 DAP. Results of observation on Leaf Area Index at 60 and 90 DAP are presented in Table 6.

Leaf Area Index for maize population per hectare during observation at 60 DAP and 90 DAP was affected by the application of inorganic fertilizer NPK "Phonska” and NPK-MgO "Ecobion". At 60 DAP, the application of B = (350 kg Urea + 50 kg SP-36 + 450 kg NPK "Phonska")/ha was 4.15 have significant difference with other treatments (A, C, D, E, and F). At 90 DAP, the application of E = (200 kg Urea + 400 kg "Ecobion")/ha and F = (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha were highest, 4.43, and E (250 kg Urea + 400 kg NPK-MgO "Ecobion")/ha is 4.35.

Leaf Area Index (LAI) that derived from the research was 2.5, on average, so that more dry matters will be accumulated in stem, as stated by Goldsworthy [10], optimal Leaf Area Index (LAI) to produce maximum dry matter, ranges from 2.5 to 5, depends on the planting area. If the Leaf Area Index is beyond the optimal limit, dry matter will be accumulated in stem.

### Table 6. Effect of NPK-MgO "Ecobion” on Leaf Area Index (LAI) per Plant at 60 DAP and 90 DAP, Rainy Season-I, 2017, Singosari, Malang

| Treatment | Leaf Area Index (LAI) per Plant 60 DAP * | Leaf Area Index (LAI) per Plant 90 DAP * |
|-----------|------------------------------------------|------------------------------------------|
| A         | 3.82 a                                   | 4.61 a                                   |
| B         | 4.78 b                                   | 6.14 cd                                  |
| C         | 5.12 bc                                  | 5.69 b                                   |
| D         | 5.35 c                                   | 5.86 bc                                  |
| E         | 5.76 d                                   | 6.11 cd                                  |
| F         | 5.82 d                                   | 6.36 d                                   |
| CV        | 8.49                                     | 6.00                                     |

Notes: Numbers followed by the same letter in the same column show no significant difference at level 5% on DMRT test; ns = not significant; s = significant
Notes: Numbers followed by the same letter in the same column show no significant difference at level 5% on DMRT test; ns = not significant; s = significant

3.3. Yield Component

3.3.1. Weight of 100 Grains, Ear Weight, and Yield of Dry Grains. Results for analysis of variance showed that inorganic fertilizer from NPK-MgO "Ecobion" affected on weight of 100 grains and yield of dry grains per ha, but it did not affect on ear of maize. Results of observation on 100 grains, ear weight, and yield of dry grains per ha are presented in Table 7 and Figure 1.

Fertilization treatment by different dose of NPK-MgO "Ecobion" (E = 200 kg Urea + 400 kg NPK-MgO "Ecobion")/ha and F = 200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha showed significant difference against weight of 100 grains, even though it did not show any significant difference with the treatment D = (200 kg Urea + 300 kg NPK-MgO "Ecobion")/ha. The treatment of E and F by the application of NPK-MgO "Ecobion" on weight of 100 grains showed significant difference with the treatment of B that was applied with NPK "Phonska". The lowest weight of 100 grains was resulted from the treatment without fertilization (A), 34.30 gram.

Table 7. Effect of Inorganic Fertilization using NPK-MgO "Ecobion" on Weight of 100 Grains, Ear Weight, and Yield of Dry Grains with Water Content 14%, Rainy Season-I, 2017, Singosari-Malang

| Treatment | Weight of Grains (gram) a | Weight of Ear (ton/ha) b | Yield of Dry Grains with Water Content 14% (ton/ha) b |
|-----------|---------------------------|--------------------------|------------------------------------------------------|
| A         | 34.30 a                   | 147.55 a                 | 3.98 a                                               |
| B         | 36.30 ab                  | 272.72 b                 | 6.48 b                                               |
| C         | 35.85 ab                  | 274.80 b                 | 6.27 b                                               |
| D         | 39.20 bc                  | 275.84 b                 | 7.60 c                                               |
| E         | 41.35 c                   | 276.53 b                 | 8.33 cd                                              |
| F         | 41.45 c                   | 284.65 b                 | 8.72 d                                               |
| CV        | 13.45                     | 9.56                     | 10.63                                                |

Notes: Numbers followed by the same letter in the same column show no significant difference at level 5% on DMRT test; ns = not significant; s = significant

Weight of ear showed no significant difference over the whole fertilization treatments, except on the plant, which did not have the fertilizer application. The heaviest weight of ear was significantly resulted from the application of inorganic fertilizer NPK-MgO "Ecobion” for about 500 kg/ha along with the application of 200 kg Urea/ha. The heaviest weight of ear was resulted from fertilization of F = (200 kg Urea + 500 kg NPK-MgO “Ecobion”)/ha, 284.65 gram, even though it has no significant difference with the treatment using NPK-MgO “Ecobion” and NPK "Phonska" (B, C, D, and E), while the lowest was resulted from the plant without the application of A (147.55 gram).
Figure 1. Graphic for Yield of Dry Grains

According to Sirappa and Razak [8], N and P will keep to be absorbed by the plant and approaching maturity, while K is absorbed during the silking. Most of N and P are transported to the growth point, stem, leaf, and staminat, and then moved to the seed.

The highest yields of dry grain were significantly derived from treatment $F = (200 \text{ kg Urea} + 500 \text{ kg NPK-MgO "Ecobion"})$/ha, 8.72 ton/ha dry grains, but it did not show significant difference if dose of NPK-MgO "Ecobion" was being reduced 400 kg/ha along with the application of Urea 250 kg/ha (treatment E), 8.33 ton/ha dry grains. Yield of dry grains that resulted from the application of $F = (200 \text{ kg Urea} + 500 \text{ kg NPK-MgO "Ecobion"})$/ha showed significant difference with the treatment that applied NPK "Phonska", 6.48 ton/ha. Increase dose of NPK-MgO "Ecobion" followed by the increase yield of dry grains, but the increase application of 500 kg/ha did not show any significant difference on the resulted yield with the dose of 400 kg NPK-MgO "Ecobion"$/ha. The increase yield was resulted by the application of NPK-MgO "Ecobion", 36.52 – 54.36%, in comparison with without fertilizer application [3,11].

In accordance with Herawati and Peter [14], the application of NPK "Phonska" 600 kg/ha (90 kg N +90 kg P$_2$O$_5$ + 90 kg K$_2$O) that parallel to 200 kg Urea + 250 kg SP-36 + 150 kg KCl, in general, have positive effect on parameter as observed on the hybrid production, such as weight of ear, weight of seeds per ear, and weight of dry grains per hectare (7.51 ton/ha), which are heavier than the treatment using other fertilizer. Balanced combination of N, P, and K may affect the efficient use of nutrients on the hybrid maize. Different combination of N, P, and K will change the efficient use of N, P, and K as well. It indicates the effect of interaction among nutrients on efficient use of other nutrient.

The application of complete fertilizer (NPK) produces higher yield than without the one of the nutrients application of N, P, and K [6]. Balanced combination of N, P, and K may affect efficient use of nutrients [13]. Excessive application of N or K on maize may cause more dominant vegetative growth than the generative one, so that it will reduce the yield. Therefore, balanced application of N, P, and K is required. Balanced and sufficient application of fertilizer is one of the key factors in increasing production and productivity of maize. Yield and profit will increase along with the application of balanced fertilizers of N, P, and K [9].

During R3 phase (pre-maturity phase), when the seed filling is in transparent form or turns like milk, water content of the seed is still 80%. During R3 phase, the seed filling turns from liquid into milky form, starch accumulation runs quickly, seed color can be seen but water content of the seed is 80%, while in R6 phase (physiologically mature, seeds on ear have reached maximum dry weight. Water content of the seed ranges 30 – 35% and NPK absorption by the plant has reached 100% [8,13].

N, P, and K are essential nutrients, which are highly required for growth and production of hybrid maize. For each ton of the yielded seeds, it requires 27.4 kg N, 4.8 kg P, and 18.4 kg K (Cooke, 1985), and somehow maize may absorbs 23 – 34 kg N, 6.5 – 11 kg P$_2$O$_5$, and 14 – 42 kg K$_2$O, therefore appropriate nutrient management are needed, so that the need for nutrients can be fulfilled optimally [2].

Growth of maize highly requires macronutrients, such as N, P, and K. Nutrient availability of N whether in NPK "Phonska" (15% N), as well as in NPK-MgO "Ecobion" (13,91% N) are highly required by the plant, so that weight of dry grains increase. If N supply reduces during the growth phase,
the plant will transfer N from leaf to seed, which in turn, will accelerate leaf aging [2,9]. The application of N = 350 kg/ha, P = 150 kg/ha, and K = 100 kg/ha resulted the highest yield of dry grains for about 8.43 ton/ha for varietal hybrid of Bisi-16 [4].

3.4. RAE Value

Fertilizer effectiveness is shown by RAE (Relative Agronomic Effectiveness) value on the recommended-standard fertilizer. In this experiment, the standard treatment used treatment 2, such as 350 kg Urea/ha +50 kg SP-36/ha + 450 kg NPK "Phonska"/ha. Dry grain yield that resulted from the treatment is used as standard of RAE 100%. Result of RAE analysis concerning with the effect of NPK-MgO "Ecobion" on growth and yield of maize is presented in Table 8.

### Table 8. Relative Agronomic Effectiveness (RAE) Value that relates to the Treatment of Inorganic Fertilizer NPK-MgO "Ecobion" on Yield of Maize

| Treatment | Yield of Dry Grain (ton/ha) | Relative Agronomic Effectiveness (RAE) Value (%) |
|-----------|----------------------------|-----------------------------------------------|
| A         | 3.98                       | -                                             |
| B         | 6.48                       | 100                                           |
| C         | 6.27                       | 91.6                                          |
| D         | 7.60                       | 144.8                                         |
| E         | 8.33                       | 174.0                                         |
| F         | 8.72                       | 189.6                                         |

The results show that treatment D = (200 kg Urea + 300 kg NPK-MgO "Ecobion")/ha, E = (200 kg Urea + 400 kg NPK-MgO "Ecobion")/ha and F = (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha) have Relative Agronomic Effectiveness/RAE values higher than dari 100 that include 14.8%, 174.0% and 189.6%, respectively, in comparison with the treatment using fertilizer C = (350 kg Urea + 50 kg SP-36 + 200 kg NPK-MgO "Ecobion")/ha, which has lower effectiveness value. Those three treatments (D, E, and F) are effective in increasing yield of dry grains. It is indicated by RAE value, which is higher than 100. High effectiveness, 189.6%, was obtained from treatment F by the application of inorganic fertilizer 500 kg NPK-MgO "Ecobion")/ha combined with 200 kg Urea/ha. The application of inorganic fertilizer NPK-MgO "Ecobion" that effectively increase the maize yield, which was shown by RAE value that is higher than 100 [7, 14].

3.5. Financial Analysis on Corn Farming

Analysis of efficiency is based on input and output prices during the testing. When fertilizers were tested, both input and output prices are as follow: Urea = IDR. 1,800/kg, SP-36= IDR. 2,000/kg, NPK Phonska = IDR. 2,300/kg, and NPK-MgO "Ecobion" = IDR. 3,750/kg. Selling price of dry grain is IDR. 3,700/kg. (Table 9).

This analysis counted any change or extra cost as a result of different fertilizer application, farm cost and output value due to the application of different fertilizer. Net income (profit) is counted by subtracting the selling value of dry grain yield with fertilizer cost and harvest cost, and other farming costs (workforce and production facilities), so that fertilization profit can be counted. Data of financial analysis counting for farm operation is based on results of experiment at site in Singosari, Malang, during Rainy Season –I, 2017.

Fertilization (200 kg Urea + 500 kg NPK-MgO "Ecobion")/ha shows R/C ratio 2.77 and B/C ratio 1.56, while the application of fertilizers (350 kg Urea + 50 kg SP-36 + 450 kg NPK "Phonska")/ha showed R/C ratio was 2.17 and B/C ratio was 1.86. Fertilizer application of 450 kg NPK “Phonska”/ha, as well as 350 kg Urea/ha and 50 kg SP-36/ha showed net income for about IDR 12,916,000 lower than net income that applied 500 kg NPK-MgO "Ecobion"/ha and 200 kg Urea/ha was IDR. 21,657,500. Price of NPK-MgO "Ecobion" IDR. 3,750, and price of NPK "Phonska" is IDR. 2,300/kg (subsidized
price). The application of NPK-MgO "Ecobion" technically deserved to be developed because it has R/C ratio > 1, and it is economically profitable because it has B/C ratio > 1.

**Table 9.** Analysis on Farm of Maize/ha by the Application of 350 kg Urea/ha + 50 kg SP-36/ha + 450 kg NPK “Phonska” and 200 kg Urea/ha + 500 kg NPK-MgO "Ecobion")/ha, Rainy Season-I, 2017, Singosari-Malang

| Activity and Means                  | Unit   | Unit Price (IDR) | 350 kg Urea/ha + 50 kg SP-36/ha + 450 kg NPK "Phonska"/ha | 200 kg Urea/ha + 500 kg NPK-MgO "Ecobion"/ha |
|-------------------------------------|--------|----------------|-----------------------------------------------------------|---------------------------------------------|
| A.                                 |        |                | Vol. (kg) Amount (IDR)                                    | Vol. (kg) Amount (IDR)                      |
| 1. Land preparation                | HKP    | 45,000         | 30 1,350,000                                              | 30 1,350,000                                |
| 2. Planting                        | HKW    | 35,000         | 20 700,000                                                | 20 700,000                                  |
| 3. Weeding I                       | HKW    | 35,000         | 15 525,000                                                | 15 525,000                                  |
| 4. Weeding II                      | HKW    | 35,000         | 15 525,000                                                | 15 525,000                                  |
| 5. Fertilization                   | HKP    | 45,000         | 15 675,000                                                | 15 675,000                                  |
| 6. Pest & Disease Control          | HKP    | 45,000         | 15 675,000                                                | 15 675,000                                  |
| 7. Harvest                         | HKP    | Contract work  | - 1,620,000                                               | - 2,287,500                                 |
| 8. Transporting                    | HKP    | 45,000         | 10 450,000                                                | 10 450,000                                  |
| 9. Drying                          | HKP    | 35,000         | 10 350,000                                                | 10 350,000                                  |
| Total Workforce                    |        |                | 7,395,000                                                 | 8,062,500                                   |
| B.                                 |        |                |                                                           |                                             |
| 1. Seeds                           | kg     | 75,000         | 20 1,500,000                                              | 20 1,500,000                                |
| 2. Urea                            | kg     | 1,800          | 350 630,000                                               | 200 360,000                                 |
| 3. NPK-MgO "Ecobion"               | kg     | 3,750          | - 500 1,875,000                                           |                                             |
| 4. NPK “Phonska”                   | kg     | 2,300          | 450 1,035,000                                             |                                             |
| 5. Pesticide                       | kg     | 25,000         | 10 400,000                                                | 10 400,000                                  |
| Total Means                        |        |                | 3,665,000                                                 | 4,135,000                                   |
| Total Cost                         |        |                | 10,060,000                                                | 12,197,500                                  |
| Maize Yield (ton/ha)               |        |                | 6.48                                                      | 8.87                                        |
| Selling Price (IDR/kg)             |        |                | 3,700                                                     | 3,700                                       |
| Gross Income (IDR)                 |        |                | 23,976,000                                                | 32,819,000                                  |
| Net Income (IDR)/profit            |        |                | 12,916,000                                                | 20,621,500                                  |
| R/C ratio                          |        |                | 2.17                                                      | 2.69                                        |
| B/C ratio                          |        |                | 1.86                                                      | 1.59                                        |

Notes: 1). Cost of harvest by contract work IDR. 250.-; 2). Selling Price for Dry Grains of Maize IDR. 3,700.-/kg

In general, based on the technological application aspect, the application of inorganic fertilizer of NPK-MgO "Ecobion" and NPK "Phonska" has further prospect and it must be developed in the future. It is shown by R/C-ratio value, which is higher than 1 (>1). It means that the fertilizing technology, which has been introduced to the farmers, is better and economically suitable. R/C ratio or B/C ratio is profitable if R/C ratio or B/C ratio is higher than one. R/C ratio or B/C ratio > 1 means that the farming operation has been run efficiently. However, based on the farm aspect, such technology with inorganic fertilizer application of NPK-MgO "Ecobion" must be developed in the future. Profit and farm cost aspects are essential and must be concerned, whereas the maize farmers, in general, have limited finance and low productivity. It is expected that each agricultural technology will be able to be adopted by the farmer. Therefore, the related technology should be easily applicable and provide more profits [15,16–18].
4. Conclusion
Fertilizing management $F = \frac{(200 \text{ kg Urea} + 500 \text{ kg NPK-MgO "Ecobion")}}{\text{ha}}$ promote the highest vegetative growth (plant height, stem diameter, Leaf Area (LA), and Leaf Area Index (LAI)) and Yield Components (weight of 100 grains, ear weight per plant, and yield of dry grains) showed the highest yields in comparison with other fertilizing management. Fertilizing management $F = \frac{(200 \text{ kg Urea} + 500 \text{ kg NPK-MgO "Ecobion")}}{\text{ha}}$ produced the highest grain yield 8.72 ton/ha and increase higher yield 54.36% than without fertilization and showed 189.6% effectiveness. Financial analysis result of maize farm by the application of fertilizing management = $(200 \text{ kg Urea/ha} + 500 \text{ kg NPK-MgO "Ecobion")}/\text{ha}$ showed the highest grain yields 8.72 ton/ha, and gross income IDR. 33,855,000, as well as the highest net income (profit) was IDR. 21,657,500 with R/C -ratio = 2.77.

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