Nutrition management on irrigated rice fields to increase maize productivity

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Abstract. Balanced fertilization is the main key to increase maize productivity. This paper aims to evaluate the recommendations of fertilizing N, P and K on the growth and production of maize on irrigated paddy fields. The study was conducted in three provinces of Lampung, Banten and Central Java. The experiment was carried out using a randomized block design with incomplete factorial. The number of treatments was 12 and each had 3 replications. Fertilization treatments were 4 levels of each N, P and K included Urea (0, 150, 300, 450 kg ha\(^{-1}\)), SP-36 (0, 100, 200, 300 kg ha\(^{-1}\)) and KCl (0, 50, 100, and 150 kg ha\(^{-1}\)). The results showed that the yield of dry shelled maize for the three locations was obtained from a combination of fertilizer treatment with Urea fertilizer doses of 450 kg ha\(^{-1}\), SP-36 200 kg ha\(^{-1}\), and KCl 100 kg ha\(^{-1}\), with the respective results for the Lampung 7.77 t ha\(^{-1}\), Banten 7.58 t ha\(^{-1}\), and Central Java 7.67 t ha\(^{-1}\). Fertilization of N and K affected the increased stover weight and dry weight of maize kernels in Lampung, Banten, and Central Java. Meanwhile, P fertilization could not increase the stover weight and yield of maize.

1. Introduction
The Ministry of Agriculture as a state institution has many functions, including formulating and stipulating policies in terms of increasing the productivity of rice, maize and soybeans through research and development approaches as well as innovation in agriculture. Internationally maize is the third most important commodity under wheat and rice [1]. This is intended to maintain national food security, especially in relation to self-sufficiency in rice, maize and soybeans (Pajale) [2]. Pajale self-sufficiency can be achieved through two specific approaches, namely: (1) increasing the quality of intensification (through the application of balanced fertilization) and improving irrigation networks, as well as increasing the cropping index, and (2) expanding agricultural areas by opening new rice fields.

Maize is one of the three leading commodities that have high priority to be developed in various ecosystems, including irrigated rice fields, rainfed rice fields and acid dry land. Maize is one of the cereals that has high strategic value related to its function as a source of carbohydrates apart from rice, as well as a source of animal feed [3]. However, the results of the study show that efforts to increase maize production still face various obstacles so that domestic maize production has not been able to meet national needs [4]. Halliday and Trenkel [5] stated that crops currently cultivated, such as maize, generally require nutrients of various types and in relatively large quantities, including nutrients N, P, and K, so it is almost certain that without fertilization, high crop yields will not be possible. Therefore, the application of the concept of balanced fertilization needs to be considered and a concern if maize production is to increase significantly [6].
The results of several studies indicate that lowland farmers are currently very dependent on the use of superior varieties and inorganic fertilizers to increase maize yields. The use of high yield potential high yielding varieties that are responsive to fertilization results in higher fertilizer use compared to less responsive varieties. On the other hand, the fertility of rice fields in Indonesia is quite varied. The results of the evaluation of paddy soil fertility with parameter indicators of C-organic status, soil P and K status indicate that the intensification of lowland soil organic C status has decreased to below 2%, while soil P content which was previously dominated by moderate status has now increased to high status. On the other hand, the status of soil K content occurs, where most of the paddy fields have decreased to medium and low status. This is due to the fact that most farmers only use Urea and SP-36 fertilizers and rarely or never add KCl or do not return the leftover straw [7,8]. This in the long term causes an imbalance of nutrients in the soil which results in a decrease in soil fertility and crop production and farmers income. For this reason, the recommendation for site-specific balanced fertilization for maize plants needs to be evaluated. In addition, the results of several studies indicate that plant survival cannot be separated from the role of both macro and micro nutrients available in the soil and those needed by plants. The balance between the need and availability of nutrients needs to be considered in plant cultivation, so that plants can grow and develop optimally in accordance with their genetic potential.

Based on the above information, it can be argued that fertilizer is an important means of agricultural production in increasing maize production. To achieve optimal production and increase farmers’ income and be environmentally friendly, efforts should be made to use fertilizers to be effective and efficient. For optimizing plant growth, it requires the intake of several elements in balanced quantities including nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). The application of the concept of balanced fertilization based on soil testing is one of the efforts to achieve the above targets. However, the results of several studies show that farmers often ignore the correct 6 (type, dose, time, method, price, and quality) in applying fertilizer.

This paper aim to evaluate fertilization recommendations for N, P, and K on the growth and production of maize in irrigated rice fields.

2. Materials and methods
The research was conducted in three locations of Indonesia regions, namely: i) Braja Selebah Village, Brajaharjosari Sub-District, East Lampung District, Lampung Province, ii) Gunung Cupu Village, Cimanuk Sub-District, Pandeglang District, Banten Province, and iii) Kebonan Village, Karanggede Sub-District, Boyolali District, Central Java Province. At the beginning of the activity, field research was determined based on the status of P and K nutrients, varying from medium to high. The locations were chosen based on the map of P and K nutrient status at a scale of 1:250,000 in 2010-2014 in Java and Sumatra [9]. Research on N, P, and K fertilization on maize was carried out in farmers' rice fields during the 2016 planting season.

The experiment was carried out using a randomized block design with incomplete factorial treatment patterns. The number of treatments was 12 and each treatment was repeated 3 times. The treatment was a combination of N, P, and K fertilization plus control treatment and one treatment with varieties commonly grown by farmers. Treatment of varieties commonly used by farmers is carried out to obtain a correction factor for high yield potential maize.

Fertilization treatments were applied for each of 4 levels of N, P, and K fertilizer doses. The doses of N fertilizer that were tried were 0, 150, 300, 450 kg urea ha⁻¹, the dosage of P fertilizer was 0, 100, 200, 300 kg SP-36 ha⁻¹ and the dosage of K fertilizer was 0, 50, 100 and 150 kg KCl ha⁻¹. Plus, control treatment (without NPK fertilizer), and treatment using varieties commonly grown by local farmers.

The maize variety used was the Bisi 2 variety. Maize seeds were planted with a spacing of 30 cm x 75 cm planted with 2 seeds per hole. The treatment plots were 5 x 4 m in size, between the plots a ditch was made with a width of 30 cm and a depth of 20 cm, this was made to prevent contamination between treatments. Pest prevention, weeding and irrigation according to PTT standards. Observations were made on the growth and yield of maize.
Soil samples before being treated were taken every replication (3 samples per location) at the time of planting preparation using a composite taken from each plot. All samples were put together, mixed until homogeneous and taken +1 kg, air dried, crushed and sieved with a 2 mm diameter sieve. Soil samples were analyzed: texture of sand, dust and clay, pH (H₂O and KCl 1N), C-organic (potassium dichromate or Kurmis), N-total (Kjeldahl), P and K extracted 25% HCl, and available P (extracted from Bray 1), Ca, Mg, K, Na and KTK (NH₄-Ac 1N pH 7), and base saturation (KB).

Samples of maize kernels and stover were taken randomly in each treatment from the yield of about 1 kg when harvested, then put into paper bags, oven-dried at 60°C for 48 hours. Then it was milled and analyzed for N, P, and K nutrients.

Growth and yield data were analyzed quantitatively using the SPSS program. The treatment response was analyzed by analysis of variance (ANOVA) followed by analysis between treatments with Duncan (DMRT) with a 95% confidence level, while the response curve to fertilization was using the regression/quadratic method.

3. Results and discussion

3.1. Results of soil analysis at the experimental location

The soil in the three locations has a clay texture, with a clay content of more than 65% compared to the percentage of dust and sand fractions. Soil in the Braja Selebah location, Lampung reacted with a low pH, around 4.5, while the acidity level of the soil in Mount Cupu, Pandeglang and Kebonan, Boyolali was classified as slightly acidic with a pH range of 5.5-6.4. With low to moderate acidity, it can be assumed that the soil has undergone further development and is generally dominated by 1:1 clay minerals (kaolinite and halloysite). Soil that reacts with acid can reduce the availability of nutrients because it is fixed by Al, Fe, and or Mn which dominate the soil traps. Fe element is available in a lot of acidic conditions, apart from being poisonous to plants, it can also cover the roots of plants which result in plant roots being unable to absorb nutrients, and can bind P nutrients. Such soil conditions can result in stunted growth of maize plants due to lack of nutrients and got poisoned [10].

Many factors influence the level of soil acidity, including the nature of water inundating the soil, the parent material for forming the soil, and the land management methods that have been carried out by farmers, especially in relation to the type of fertilizer used. The results showed that the availability of nutrients in the soil that could be absorbed by plants would be optimal if the soil acidity level was close to neutral [11].

The levels of C-organic and N-organic for the three locations were classified as low and the C/N ratio was low, so that the levels of N, S, and P were low. Schroeder [12] stated that organic matter is the main source of the elements N, S, and P, where 98% N, 60-96% S, and 25-60% P are sourced from organic matter. Low levels of C-organic soil are thought to be related to very little return of plant litter by farmers, in addition to the relatively fast and high decomposition of organic matter due to high temperatures. The P₂O₅ and K₂O levels of the 25% HCl extract respectively were high; available P levels (Bray 1) were low; P retention is high, so the availability of soil phosphate and the efficiency of low phosphate fertilization.

The cation exchange capacity (CEC) is moderate. The level of base saturation for the location of Braja Selebah, Lampung was low, while for the soil of Mount Cupu, Pandeglang and Kebonan, Boyolali was classified as medium to high. This shows that the soil fertility level in the three locations is different from one another [13]. Soils with a low alkaline saturation level generally indicate that they have been heavily leached. Soil chemical buffering capacity is weak, so that cations such as K, Ca, and Mg are easily leached which results in the soil being poor in nutrients and the exchange complex will be dominated by Al ions which can poison plants. Thus, in advanced soils such as Ultisol, fertilization efficiency is low and Al toxicity is high. Sanchez [14] added that in advanced soils such as Ultisols with acidic pH, the form of phosphate that dominates the soil is iron phosphate or aluminum phosphate, very little in the form of calcium phosphate.
Table 1. The physical and chemical properties of the soil in the Village of Braja Selebah and Kebonan used in the research.

| Parameter                              | Braja Selebah | Gunung Cupu | Kebonan |
|----------------------------------------|---------------|-------------|---------|
| Texture (pipette)                      | clay          | clay        | clay    |
| Sand (%)                               | 18            | 9           | 4       |
| Silt (%)                               | 15            | 22          | 14      |
| Clay (%)                               | 67            | 69          | 82      |
| pH (1:5)                               | 4.50          | 5.50        | 6.44    |
| H₂O                                    | 3.50          | 4.58        | 5.30    |
| Organic matter                         |               |             |         |
| C (%)                                  | 1.67          | 1.36        | 1.28    |
| N (%)                                  | 0.20          | 0.12        | 0.11    |
| C/N                                    | 8             | 11.50       | 12.76   |
| P-Bray (mg kg⁻¹)                       | 8             | 6           | 8       |
| P-Olsen (ppm)                          | 32.50         | 7.73        |         |
| Extract (HCl 25%)                      |               |             |         |
| P₂O₅ (mg 100 g⁻¹)                      | 36            | 112.70      | 48.56   |
| K₂O (mg 100 g⁻¹)                       | 9             | 15          | 5.83    |
| Cation exchange rate (NH₄-Asetat 1N, pH7) |   |             |         |
| K (cmol c⁻¹ kg⁻¹)                      | 0.15          | 0.38        | 0.24    |
| Ca (cmol c⁻¹ kg⁻¹)                     | 1.66          | 5.80        | 15.50   |
| Mg (cmol c⁻¹ kg⁻¹)                     | 1.12          | 2.54        | 6.28    |
| Na (cmol c⁻¹ kg⁻¹)                     | 0.06          | 0.12        | 0.66    |
| Sum (cmol c⁻¹ kg⁻¹)                    | 2.998         | 8.84        | 22.67   |
| CEC (cmol c⁻¹ kg⁻¹)                    | 14.49         | 18.50       | 11.20   |
| Base saturation (%)                    | 21            | 47.95       | >100    |

3.2. The effect of fertilization on the growth of maize plants

The results of statistical analysis showed that fertilization had a significant effect on the height of the maize plant at harvest. The highest plant height at harvest for the three locations was obtained from N2P2K2 treatment, which 243 cm for Braja Selebah, 235 cm for the Mount Cupu location, and 241 for the Kebonan location, Boyolali, with a dose of urea fertilizer of 300 kg ha⁻¹, SP-36 200 kg ha⁻¹, and KCl 100 kg ha⁻¹. Table 2 also shows that the application of N and K affected plant height, while P did not have a significant effect. This is thought to be caused by the low levels of N and K in the soil so that it is very responsive to N and K. The elements of N and K fertilization greatly influenced the growth and yield of maize on Typic Hapludalfs [15]. Sutriadi et al. [16] also added that maize planted on Haplusterts soil in Jeneponto, South Sulawesi, responded highly to N, P, and K fertilization. The response rate of maize plants to fertilizers is highly dependent on the status of N, P, and K nutrients in the soil. Therefore, fertilizers containing macro nutrients N, P, and K in plant cultivation are very important to add one or more nutrients to the soil [17].
Table 2. The effect of fertilization on the height of maize plants at harvest in Braja Selebah, East Lampung, Gunung Cupu, Pandeglang, and Kebonan, Boyolali DS. 2016.

| Treatments  | Plant height (cm) | Braja Selebah | Gunung Cupu | Kebonan |
|-------------|-------------------|---------------|-------------|---------|
| N0P0K0      |                   | 202.60 a      | 198.35 a    | 201.45 a* |
| N0P2K2      |                   | 214.40 ab     | 210.19 ab   | 212.24 ab |
| N1P2K2      |                   | 221.30 bc     | 217.10 bc   | 219.13 bc |
| N2P2K2      |                   | 229.90 cde    | 223.52 cde  | 227.62 cde |
| N3P2K2      |                   | 225.00 bc     | 213.95 bc   | 223.95 bc |
| N2P0K2      |                   | 221.30 bc     | 212.45 bc   | 222.45 bc |
| N2P1K2      |                   | 226.70 bc     | 220.30 bc   | 225.34 bc |
| N2P3K2      |                   | 228.00 cd     | 218.35 cd   | 228.45 cd |
| N2P2K0      |                   | 231.50 cde    | 219.25 cd   | 229.35 cd |
| N2P2K1      |                   | 234.60 cde    | 221.48 cde  | 231.68 cde |
| N2P2K3      |                   | 241.97 de     | 227.35 de   | 239.46 de |
| N2P2K2      |                   | 242.80 e      | 235.36 de   | 240.46 de |

Note. * = numbers in that column same followed by the same letter means no different real at the 5% level based on the DMRT test.

3.3. The effect of fertilization on maize yield

3.3.1. Braja Selebah Village, Brajaharjosari Sub-District, East Lampung District. Fertilization can increase the biomass and yield of maize (figure 1). The yield of maize in the treatment without N fertilization (N0P2K2) was almost the same in the N0P0K0 treatment (without fertilizer). N nutrient fertilization can increase the biomass and yield of maize by 10 and 122%, respectively. K nutrient fertilization increased biomass 25% and maize yield 46%. Meanwhile, P nutrient fertilization did not increase the biomass and yield of maize.

The effect of N nutrient fertilization gave maize yield which was still linear and had not yet obtained the maximum dose and yield. The results of K nutrient fertilization obtained quadratic linear results for biomass and maize yield. The highest maize yield with K nutrient fertilization was 6.26 t ha\(^{-1}\) with a maximum fertilization of 69.5 kg K\(_2\)O ha\(^{-1}\) or 115.8 kg KCl ha\(^{-1}\). The highest dry biomass (3.87 t ha\(^{-1}\)) was achieved by fertilizing 61.5 kg K\(_2\)O ha\(^{-1}\) or 102.5 kg KCl ha\(^{-1}\). Thus, it can be said that the maximum K nutrient fertilization for maize in Braja Selebah is around 100-115 kg KCl ha\(^{-1}\).

Usman et al. [18] said that the dose of KCl fertilizer has significant effect on plant height, stem diameter, leaf number, and the yield of maize, planted in Gowa, South Sulawesi.

3.3.2. Gunung Cupu Village, Cimanuk Sub-District, Pandeglang District. The yield of maize in Gunung Cupu Village can be increased by fertilizing the N and K nutrients (figure 2). The yield of maize on N0P2K2 treatment or without N fertilization was almost the same as that of un-fertilized maize (N0P0K0). The yield of maize in the K (N2P2K0) nutrient-free treatment was higher than that without N fertilization or N0P2K2 treatment. Meanwhile, without P fertilization (N2P0K2) the yield of maize was the same as that fertilized with N, P, and K (N2P2K2). This means that the response to maize yield can increase if N nutrient is fertilized, followed by K nutrient. The balance between macro nutrients, especially N, P, and K determines the productivity level of maize [19,20].
The relationship between N fertilization and maize yield was still linear, meaning that the increased dose of N fertilizer still increased maize yield. For this reason, the maximum maize yield has not been achieved and the maximum dose cannot be determined. The relationship between K fertilization and maize biomass was still linear, with maize yields quadratic. The maximum maize yield of 6.84 t ha\(^{-1}\) was achieved by fertilizing K 99.5 kg K\(_2\)O ha\(^{-1}\) or 165.8 kg KCl ha\(^{-1}\). In India N fertilization significantly increased maize growth and yield.

3.3.3. *Kebonan Village, Karanggede Sub-District, Boyolali District.* The productivity level of maize was influenced by the addition of N and K fertilizers, while the addition of P did not increase the yield of maize. The yield of maize in the treatment without P fertilization (N2P2K2) was the same as the treatment without P fertilization (N2P0K2) (figure 3). Maize yields increased, especially when fertilized with N and followed by K fertilization [21].

The relationship between N fertilizer dose and increasing maize yield is linear, meaning that N fertilization up to a dose of 202.5 kg N ha\(^{-1}\) still increases maize yield. The graph of the relationship between the K fertilization dose and the biomass and yield of maize is linear-quadratic. The maximum dose of K nutrient fertilization is 65.08 kg K\(_2\)O ha\(^{-1}\) or 108 kg KCl ha\(^{-1}\) for maize yield, and 60.75 kg K\(_2\)O ha\(^{-1}\) or 101.25 kg KCl ha\(^{-1}\). Soerjandono [22] said that in Typic Kandiudox soils with low to moderate nutrient status, giving K significantly increased the weight of maize stalk and shelled.

**Figure 1.** The effect of N, P, K fertilization on maize yield (a), N fertilization (b), and K fertilization (c) in Braja Selebah Village.
3.3.4. Nutrient uptake. Fertilization of N nutrient can increase the uptake of N nutrients from the seeds, and increase the uptake of N nutrients from the plants in the village of Kebonan. Nutrient N is a nutrient that is needed in increasing maize yield, hybrid maize yields in South-Western Iran can increase from 670-956 g m$^{-2}$ with the addition of N fertilizer 90 kg ha$^{-1}$ [12]. K fertilization can increase K nutrient uptake through maize kernels, but does not increase through maize stalks. Meanwhile, P nutrient uptake did not increase with P fertilization in three locations.
Figure 3. The effect of N, P, K fertilization on maize yield (a), N fertilization (b), and K fertilization (c) Kebonan Village.

Table 3. Uptake of N, P, and K nutrients in stover and maize kernels.

| Treatment   | Uptake of N nutrients in seeds (kg ha⁻¹) | Uptake of N nutrient in stover (kg ha⁻¹) | Uptake of P nutrients in seeds (kg ha⁻¹) | Uptake of P nutrient in stover (kg ha⁻¹) | Uptake of K nutrients in seeds (kg ha⁻¹) | Uptake of K nutrient in stover (kg ha⁻¹) |
|-------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
|             | Braja Selebah | Kebonan | Gunung Puncu | Braja Selebah | Kebonan | Gunung Puncu | Braja Selebah | Kebonan | Gunung Puncu | Braja Selebah | Kebonan | Gunung Puncu | Braja Selebah | Kebonan | Gunung Puncu |
| N0P0K0      | 52.7 c        | 16.2 c  | 42.7 b       | 39.1 a        | 40.5 b  | 31.0 a       | 21.6 a         | 12.8 a   | 36.7 a       | 4.5 a         | 4.3 a   | 4.7 a       | 19.5 c         | 14.4 b   | 39.2 b       |
| N1P0K2      | 68.4 c        | 38.7 c  | 51.7 b       | 37.3 a        | 39.0 b  | 29.9 a       | 20.1 a         | 13.4 a   | 35.2 a       | 5.8 a         | 4.3 a   | 5.2 a       | 19.3 a         | 12.9 a   | 36.4 a       |
| N2P0K2      | 131.5 b       | 71.13 b | 82.3 a       | 44.5 a        | 55.9 ab | 36.4 a       | 20.6 a         | 15.4 a   | 42.7 a       | 5.0 a         | 5.1 a   | 4.3 a       | 19.2 a         | 15.4 a   | 42.7 a       |
| N3P0K2      | 162.5 c       | 97.4 a  | 97.4 a       | 42.0 a        | 62.1 a  | 35.7 a       | 21.6 a         | 12.8 a   | 36.7 a       | 4.5 a         | 4.3 a   | 4.7 a       | 19.5 c         | 14.4 b   | 39.2 b       |
| N2P0K2      | 21.6 a        | 12.8 a  | 36.7 a       | 4.5 a         | 4.3 a   | 4.7 a       | 20.1 a         | 13.4 a   | 35.2 a       | 5.8 a         | 4.3 a   | 5.2 a       | 19.3 a         | 12.9 a   | 36.4 a       |
| N2P1K2      | 19.3 a        | 12.9 a  | 36.4 a       | 4.0 a         | 3.6 a   | 4.6 a       | 20.6 a         | 15.4 a   | 42.7 a       | 5.0 a         | 5.1 a   | 4.3 a       | 19.2 a         | 15.4 a   | 42.7 a       |
| N2P2K2      | 20.1 a        | 13.4 a  | 35.2 a       | 5.8 a         | 4.3 a   | 5.2 a       | 21.6 a         | 12.8 a   | 36.7 a       | 4.5 a         | 4.3 a   | 4.7 a       | 19.5 c         | 14.4 b   | 39.2 b       |
| N2P3K2      | 19.2 a        | 15.4 a  | 42.7 a       | 5.0 a         | 5.1 a   | 4.3 a       | 20.1 a         | 13.4 a   | 35.2 a       | 5.8 a         | 4.3 a   | 5.2 a       | 19.3 a         | 12.9 a   | 36.4 a       |
4. Conclusions
Fertilization of N and K had the effect of increasing stover weight and dry weight of maize kernels in Braja Selebah Village (Lampung Province), Gunung Puncu (Banten Province), and Kebonan (Central Java Province). Meanwhile, P fertilization could not increase the stover weight and yield of maize. The limiting factors for growth, stover weight and maize yield, is especially N fertilization followed by K fertilization. The balance between macro nutrients, especially N, P, and K determines the productivity level of maize. The maximum dose of N fertilization has not been determined because the relationship between the dose of N fertilizer with stover weight and maize yield is still linear. The maximum dose of K fertilization in Braja Selebah Village is 100-115 kg KCl ha⁻¹, Gunung Puncu Village 165.8 kg KCl ha⁻¹, and Kebonan Village 101.25-108 kg KCl ha⁻¹.

References
[1] Rasheed M, Ali H and Mahmood T 2004 Impact of nitrogen and sulfur application on growth and yield of maize (Zea mays L.) crop J. Res. Sci. 15 153-157
[2] Anonim 2010 Pedoman pelaksanaan SL-PIT (Padi, Jagung, Kedelai) (in Bahasa) Direktorat Jenderal Tanaman Pangan Kementerian Pertanian
[3] Purwanto S 2008 Perkembangan produksi dan kebijakan dalam peningkatan produksi jagung (in Bahasa) Direktorat Budi Daya Sereal, Direktorat Jenderal Tanaman Pangan Bogor
[4] Sirappa M P, Tandisau P and Susanto A N 2003 Penentuan status hara dan dosis rekomendasi pupuk K untuk tanaman jagung pada lahan kering (in Bahasa) Jurnal Tanah dan Air 4 (1) 11-19
[5] Halliday D J and Trenkel M E 1998 IFA World fertilizer use manual International Fertilizer Industry Association, Paris
[6] Anonim 2006 Rekomendasi pemupukan N, P, K pada sawah spesifik lokasi (in Bahasa) Disusun sebagai narasi Keputusan Menteri Pertanian Nomor 01/SR.130/01/2006 tentang Rekomendasi Pemupukan N, P, dan K pada Padi Sawah Spesifik Lokasi Departemen Pertanian
[7] Anonim 2006 Rekomendasi pemupukan N, P, K pada sawah spesifik lokasi (in Bahasa) Disusun sebagai narasi Keputusan Menteri Pertanian Nomor 01/SR.130/01/2006 tentang Rekomendasi Pemupukan N, P, dan K pada Padi Sawah Spesifik Lokasi Departemen Pertanian
[8] Setyorini D, Nurjaya, Kasno A and Sutono 2011 Teknologi pengelolaan lahan dan pemupukan mendukung program peningkatan produksi beras nasional (P2BN) (in Bahasa) Laporan Akhir DIPA TA 2011 Balai Penelitian Tanah, BBSDLBP, Badan Litbang Pertanian
[9] Setyorini D, Nurjaya, Widowati L R and Kasno A 2007 Petunjuk penggunaan perangkat uji tanah kering versi 1.0 (in Bahasa) Balai Penelitian Tanah BB Litbang SDLBP, Badan Litbang Pertanian, Departemen Pertanian 24 p
[10] Saenong S, Syafruddin and Subandi 2005 Penggunaan LCC untuk pemupukan N pada tanaman jagung (in Bahasa) Laporan Pengelolaan Hara Spesifik Lokasi (PHSL) Kerjasama Balitsetereal dengan Potash & Phosphate Institute (PPI), Potash and Phosphate Institute of Canada (PPIC) (unpublished manuscript)
[11] Kasno A and Tia R 2013 Serapan hara dan peningkatan produktivitas jagung dengan aplikasi pupuk NPK majemuk (in Bahasa) Balai Penelitian Tanah Bogor Penelitian Pertanian Tanaman Pangan 32 (3)
[12] Schroeder D 1984 Soil fact and concepts (translate from German) PA Gething International Potash Institute, Bern
[13] Silalahi F, Saragih Y, Marpaung A, Hutabarat R, Karsina and Purba S R 2006 Laporan akhir uji pemupukan NPK pada tanaman buah (in Bahasa) Balai Penelitian Buah Kebun Percobaan Tanaman Buah (KPTB), Brastagi Medan
[14] Sanchez 1995 Nitrogen management in orchards Nitrogen Fertilization in the Environment (pp.327-380) Marcel Dekker, New York
[15] Tabri F 2010 Pengaruh pupuk N, P, K terhadap pertumbuhan dan hasil jagung hibrida dan komposit pada tanah Inseptisol Endoaquepts Kabupaten Barru Sulawesi Selatan (in Bahasa) Prosiding Pekan Serealia Nasional ISBN: 978-979-8940-29-3

[16] Sutriadi T M, Setyorini D, Nursyamsi D and Murni A M 2008 Penentuan kebutuhan pupuk kalium dengan uji K-tanah untuk tanaman jagung di Typic Kandiudox (in Bahasa) Journal of Tropical Soils

[17] Shilpashree V M, Chidanandappa H M, Jayaprakash R and Punitha B C 2012 Effect of integrated nutrient management practices on distribution of nitrogen fractions by maize crop in soil Indian Journal of Fundamental and Applied Life Sciences 1 38-44

[18] Usman M, Nangere M G and Musa 2015 Effect of three levels of NPK fertilizer on growth parameters and yield of maize-soybean intercrop International Journal of Scientific and Research Publications 5 (9) ISSN 2250-3153

[19] Alfian M S and Purnamawati H 2019 Dosis dan waktu aplikasi pupuk kalium pada pertumbuhan dan produksi jagung manis di BBPP Batangkaluku Kabupaten Gowa Sulawesi Selatan (in Bahasa) Buletin Agrohorti 7 (1) 8-15

[20] Tandisau P and Thamrin M 2014 Kajian pemupukan N, P, dan K terhadap jagung (Zea mays Linn) pada lahan kering Typic Ustropepts (in Bahasa) Balai Pengkajian Teknologi Pertanian Sulawesi Selatan

[21] Setyorini D, Rochayati S and Adiningisih S 2003 Uji tanah sebagai dasar penyusunan rekomendasi pemupukan Seri Monograf No 2 (in Bahasa) Sumber Daya Tanah Indonesia Balai Penelitian Tanah, Pusat Penelitian Tanah dan Agroklimat Badan Litbang Pertanian, Departemen Pertanian

[22] Soerjandono N B 2008 Teknik produksi jagung anjuran di lokasi prima tani Kabupaten Sumenep (in Bahasa) Buletin Teknik Pertanian