Effectiveness and recommendation of NPK-compound fertilization on maize

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Abstract. The development of maize plants in the wet tropics was experiencing problems due to a lack of nutrients, especially N, P, and K, so that to get optimal yield, additional nutrients are needed through NPK fertilization. This study aims to determine the effectiveness of fertilizers and provide recommendations for the appropriate dose of compound NPK fertilization (formulation 15:15:15, 20:10:10, and 15:8:10) to increase production, farming efficiency, and income of maize farmers. This research was conducted at the Experimental Farm of Indonesian cereal Research Institute, Maros from June until October 2020. This research was arranged in randomized block design with three replication. The treatment consists of five NPK-compound fertilizers with two doses of NPK + urea combination. The comparisons were Urea (control) and Urea + SP36+KCl (standard). The results of this research were all formulations of NPK compound fertilizers (15:15:15, 20:10:10, and 15:8:10) deserve to be recommended for maize. Recommendations for applying NPK 15:15:15 compound fertilizer to maize plants are 450 kg/ha combined with 250 kg urea/ha with a yield probability of 12 t/ha. The recommendation for applying 20:10:10 NPK compound fertilizer to maize was 350 kg/ha + 200 kg urea with a yield probability of ±11 t/ha. The recommendation for giving NPK 15:8:10 compound fertilizer for maize was 450 kg/ha combined with 250 kg urea/ha with a yield probability of 11 t/ha.

1. Introduction

Maize planting in the wet tropics was experiencing problems due to a lack of nutrients, especially N, P, and K so that additional nutrients are needed through fertilization to get optimal grain yield. Nitrogen is the most nutrient needed by the plant and often decreases in plants than other nutrients. The maize plant is very sensitive to N deficiency and responsive to N fertilization [1]; [2]. Phosphorus has a role in photosynthesis, respiration, root growth, flowering, accelerate the ripening of seeds, and increase production. Kalium is needed by maize for energy metabolism, photosynthesis, and the formation of carbohydrates [3].

Plants can only absorb part of the fertilizer added to the soil. Plants only can absorb nitrogen as much as 55-60\% [4], P as much as 20\% [5], K as much 50-70\% [6], and S as much 33\% [7]. Fertilization efficiency suppresses the negative impact of inorganic fertilizers. Excessive fertilization causes the accumulation of nutrients that damage the environment and disrupt the nutrient balance in the soil. The accumulation of P will cause Zn deficiency, K will inhibit Ca uptake, and accumulation
of S will cause changes in soil pH. To avoid the accumulation of nutrient residues is to carry out balanced fertilization based on the availability of nutrients and the results that can be obtained. Nutrient accumulation in the soil can be reduced by using a balanced combination of N, P, and K fertilizers.

Proper fertilization beside increasing fertilization efficiency, productivity, and farmers' income, can also affect the sustainability of the production system, environmental sustainability, and saving energy resources. To achieve high fertilization efficiency, it is necessary to pay attention to several things. They are (1) the type of plant/variety and nutrients requirement to achieve yield optimal; (2) nutrient availability in the soil; and (3) kinds of fertilizer as well as the right method and time of application [8].

Intensification and extensification maize program to increasing the use of fertilizers, especially urea, but less use of P and K fertilizers. The use of compound fertilizers containing relatively affordable P and K elements is expected to increase the productivity and efficiency of maize production. The use of compound fertilizers is expected to motivate maize farmers to rationalize the use of fertilizers on maize increasing productivity, fertilizer use efficiency, and farmers' income.

The necessity of information for optimal NPK compound fertilization in maize is needed to ensure satisfactory growth and productivity of maize and increase efficiency and farmers' income. This study aims to determine the effectiveness of fertilizers and provide recommendations for the appropriate dose of compound NPK fertilization (formulation 15:15:15, 20:10,10, and 15:8:10) to increase production, farming efficiency, and income of maize farmers.

2. Materials and Methods
This research was conducted at the Experimental Farm of Indonesian cereal Research Institute, Maros, South Sulawesi from June until October 2020. This research was arranged in randomized block design with three replication. The treatment consists of five NPK- compound fertilizers with two doses of NPK+ urea combination. The comparisons were Urea (control) and Urea + SP36+KCl (standard) so that there were 12 treatment combinations (Tabel 1). The maize seed used was a hybrid variety (NK-Sumo) and planted with the double row system, spacing (90-50) x 20 cm with one seed per hole. The plot size for each treatment was 7.0 m x 6.0 m.

The data were statistically analyzed using the SAS 9.0 program. To determine the differences between treatments, an analysis was carried out using Duncan Multiple Range Test (DMRT) with an accuracy level of 5%. To determine the effectiveness of compound NPK fertilizers in each formulation compared to standard fertilizers (single N, P, and K fertilizers) and control (urea use) the Relative Agronomic Effectiveness (RAE) calculation is calculated as follows:

$$RAE = \frac{\text{Grain yield on tested fertilizers} - \text{Grain yield on control}}{\text{Grain yield on standard fertilization} - \text{Grain yield on control}}$$

NPK-compound fertilizer will be effective if it has RAE value of > 95%.

To determine the economic feasibility of NPK-compound fertilizer to be applied, the following calculations was performed: cost of inputs (input), labor costs, revenue, benefit and B-C ratio. NPK-compound fertilizer will be recommended if B-C ratio is >1 and provide higher profit than control or standard fertilizer.
| No | Treatment                        | Urea | SP-36 | KCl  | NPK | Kg/ha |
|----|----------------------------------|------|-------|------|-----|-------|
| 1  | Control N                        | 400  | -     | -    | -   | -     |
| 2  | Standard (N,P,K)                 | 400  | 150   | 112.5| -   | -     |
| 3  | NPK 15-15-15                     | 200  | -     | -    | 350 |       |
| 4  | NPK 20-10-10                     | 200  | -     | -    | 350 |       |
| 5  | NPK 15-8-10                      | 200  | -     | -    | 350 |       |
| 6  | NPK 15-8-10                      | 200  | -     | -    | 350 |       |
| 7  | NPK 15-8-10 micronutrient *      | 200  | -     | -    | 350 |       |
| 8  | NPK 15-15-15                     | 250  | -     | -    | 450 |       |
| 9  | NPK 20-10-10                     | 250  | -     | -    | 450 |       |
| 10 | NPK 15-8-10                      | 250  | -     | -    | 450 |       |
| 11 | NPK 15-8-10                      | 250  | -     | -    | 450 |       |
| 12 | NPK 15-8-10 micronutrient *      | 250  | -     | -    | 450 |       |

Note: NPK-compound fertilizer was produced by PT. Pupuk Kaltim

The application of fertilizers was 50% in early planting (<10 days after planting) and 50% in 40 days after planting.

* = micronutrients are mixed at the time of application.

| No | Treatment                        | N   | P<sub>2</sub>O<sub>5</sub> | K<sub>2</sub>O |
|----|----------------------------------|-----|--------------------------|--------------|
| 1  | Control N                        | 184 | 0                        | 0            |
| 2  | Standard (N,P,K)                 | 184 | 54                       | 67.5         |
| 3  | NPK 15-15-15                     | 144.5| 52.5                    | 52.5         |
| 4  | NPK 20-10-10                     | 162 | 35                       | 35           |
| 5  | NPK 15-8-10                      | 144.5| 28                      | 35           |
| 6  | NPK 15-8-10 micronutrient        | 144.5| 28                      | 35           |
| 7  | NPK 15-8-10 micronutrient *      | 144.5| 28                      | 35           |
| 8  | NPK 15-15-15                     | 182.5| 67.5                    | 67.5         |
| 9  | NPK 20-10-10                     | 205 | 45                       | 45           |
| 10 | NPK 15-8-10                      | 182.5| 36                      | 45           |
| 11 | NPK 15-8-10 micronutrient        | 182.5| 36                      | 45           |
| 12 | NPK 15-8-10 micronutrient *      | 182.5| 36                      | 45           |
3. Results and Discussion

3.1. Result of research

3.1.1. The soil analysis

The results of soil analysis (Table 3) show that the soil was classified as sandy clay loam, the soil reaction was slightly acidic, with low N nutrient content, very low organic C, very high P, high K, high CEC, and very high base saturation. The base saturation was very high and there were no nutrients that can be toxic such as Al$^+$ and H$^+$ which can be exchanged, this indicates that the research location has high productivity for maize plants. Nutrient N was the main limiting factor because the C-organic content was classified as very low, and N was low.

| No | Characterization                          | Value   |
|----|------------------------------------------|---------|
| 1  | Texture                                  |         |
|    | Clays (%)                                | 39      |
|    | Silt (%)                                 | 46      |
|    | Sand (%)                                 | 15      |
| 2  | pH H$_2$O (1 : 2.5)                      | 6.38    |
| 3  | pH KCl (1 : 2.5)                         | 5.57    |
| 4  | C- Organic (%)                           | 0.89    |
| 5  | N-Total (%)                              | 0.13    |
| 6  | C/N                                      |         |
| 7  | P$_2$O$_5$-Bray I (ppm)                  | 130     |
| 8  | P$_2$O$_5$-HCl 25% (mg/100 g)            | 40      |
| 9  | K$_2$O-HCl 25% (mg/100 g)                | 47      |
|    | Exchanged Cation                         |         |
| 10 | K (me/100 g)                             | 0.05    |
| 11 | Cadd (me/100g)                           | 23.9    |
| 12 | Mgdd (me/100 g)                          | 1.5     |
| 13 | Nadd (me/100g)                           | 0.04    |
| 14 | Aldd (me/100 g)                          | 0       |
| 15 | H+ (me/100 g)                            | 0       |
| 16 | KTK (me/100 g)                           | 24.09   |
| 17 | Kejenuhan basah (%)                      | 100     |

Sources: BPTP of South Sulawesi laboratory, 2020.

3.1.2. The vegetative growth

The Plant height and stem diameter at 85 days after planting (DAP) were not significantly different between each treatment. The application of NPK fertilizer was not significantly different from the control treatment or with the standard on leaf chlorophyll and leaf area index (LAI), except for the treatment with NPK 20:10:10 compound fertilizer of 350 kg/ha combined with 200 kg/ha urea, which had low chlorophyll and the application of compound fertilizer NPK 15:8:10 micronutrient 350 kg/ha combined with urea 200 kg/ha (Table 4).
Table 4. The high plant, stem diameter, chlorophyll, and leaf area index (LAI) on 85 DAP in research of effectivity of NPK-Compound fertilizer on maize, 2020.

| No | Treatment | Plant height (cm) | Stem diameter (cm) | Chlorophyll (Unit) | LAI |
|----|-----------|------------------|-------------------|-------------------|-----|
| 1  | 400 Urea (control) | 198.03tn | 2.29 tn | 43.79ab | 7.23a |
| 2  | 400 Urea + 150 SP36 + 112.5 KCl (standard) | 194.33 | 2.23 | 45.34a | 7.26a |
| 3  | 350 NPK 15:15:15 + 200 urea | 200.17 | 2.21 | 44.08ab | 6.84ab |
| 4  | 350 NPK 20:10:10 + 200 urea | 195.27 | 2.23 | 38.37b | 6.46ab |
| 5  | 350 NPK 15:8:10+ 200 urea | 197.00 | 2.17 | 39.33ab | 6.60ab |
| 6  | 350 NPK 15:8:10 micronutrient + 200 urea | 187.93 | 2.16 | 41.55ab | 5.66b |
| 7  | 350 NPK 15:8:10 micronutrient *+ 200 urea | 189.60 | 2.21 | 39.33ab | 6.07ab |
| 8  | 450 NPK 15:15:15 + 250 urea | 193.45 | 2.22 | 43.38ab | 7.02ab |
| 9  | 450 NPK 20:10:10 + 250 urea | 197.30 | 2.23 | 42.83ab | 6.69ab |
| 10 | 450 NPK 15:8:10+ 250 urea | 198.60 | 2.11 | 40.99ab | 6.45ab |
| 11 | 450 NPK 15:8:10 micronutrient + 250 urea | 199.60 | 2.16 | 42.79ab | 6.69ab |
| 12 | 450 NPK 15:8:10 micronutrient *+ 250 urea | 191.47 | 2.28 | 39.67ab | 6.73ab |
|    | Average | 195.23 | 2.21 | 41.79 | 6.64 |
|    | CV (%) | 4.00 | 4.47 | 8.00 | 11.40 |

Noted: Numbers followed by different letters in the same column indicate significant differences in Duncan's test at the 5% level.

3.1.3. The yield attribute

The length of the cob on the application of NPK compound fertilizer both at the dose of NPK 350 kg/ha combined with 200 kg/ha urea and NPK 450 kg/ha combined with 250 kg/ha urea did not give a significant effect compared to the control (17.33 cm) or with standard fertilization (16.97 cm). NPK fertilization 350 kg/ha combined with urea 200 kg/ha produced a cob length of 16.33 – 17.97 cm, with NPK 450 kg/ha combined with urea 250 kg/ha produced a cob length of 16.65 – 17, 76 cm. Application of compound fertilizer NPK 15:15:15 as much as 350-450 kg/ha combined with urea 200-250 kg/ha has relatively longer cobs compared to other NPK fertilization (Table 5).

In general, cob diameter observations showed that the application of compound fertilizers did not show significant differences with the control or with the standard, except for NPK 15:8:10 + micronutrient fertilization of 450 kg/ha combined with Urea 250 kg/ha (6.82 cm) which was significantly greater than `control (5.19 cm), standard (5.20 cm), or with other NPK compound fertilizers with a diameter of 5.15-5.38 cm.

The number of seeds per cob was not affected by differences in fertilization, both plants were fertilized with NPK-compound at a dose of 350 kg/ha combined with 200 kg/ha urea or with NPK 450 kg/ha combined with 250 kg/ha urea. The highest number of seeds per cob was found in 450 kg NPK fertilization combined with 250 kg/ha urea (484.38) while the lowest number of cobs seeds was found in 350 kg/ha NPK fertilization combined with 200 kg/ha urea (448.56).

NPK-compound fertilization at a dose of NPK 350 kg/ha combined with 200 kg/ha urea or NPK 450 kg/ha combined with 250 kg/ha urea did not have a significant effect compared to the control on seed weight. However, fertilization of NPK 15:8:10, NPK 15:8:10+ micronutrient, NPK 15:8:10 + micronutrient mixed at planting time of 350 kg/ha each and combined with urea 200 kg/ha resulted in
the weight of 1000 seeds 322.3 – 329.15 g was significantly lower than standard fertilization (Urea 400+SP36 150 +KCl 112.5 kg/ha) which produced a weight of 1000 seeds 361.43 g. Application of compound fertilizer NPK 15:15:15 as much as 450 kg/ha combined with urea 250 and NPK 20:10:10 as much as 350 kg/ha combined with 200 kg/ha weights 1000 seeds which is relatively heavier than NPK fertilization which other.

Table 5. The length cob, diameter cob, number of seeds per cob, and weight of 1000 seeds in research of effectivity of NPK-Compound fertilizer on maize, 2020.

| No | Treatment                                      | Cob length (cm) | Cob diameter (cm) | Number of seeds per cob | weight of 1000 seeds (g) |
|----|-----------------------------------------------|-----------------|-------------------|-------------------------|-------------------------|
| 1  | 400 Urea (Control)                            | 17.33abc        | 5.19b             | 465.42m                 | 349.06abc              |
| 2  | 400 Urea + 150 SP36 + 112.5 KCl (Standard)    | 16.97abc        | 5.20b             | 462.57                  | 361.43a                |
| 3  | 350 NPK 15:15:15 + 200 urea                   | 17.97a          | 5.38b             | 474.91                  | 356.55ab               |
| 4  | 350 NPK 20:10:10 + 200 urea                   | 17.34abc        | 5.24b             | 461.49                  | 362.90a                |
| 5  | 350 NPK 15:8:10 + 200 urea micronutrient      | 16.33abc        | 5.17b             | 448.56                  | 322.37c                |
| 6  | 350 NPK 15:8:10 micronutrient + 200 urea      | 16.37c          | 5.15b             | 461.51                  | 328.17bc               |
| 7  | 350 NPK 15:8:10 micronutrient * + 200 urea    | 16.97abc        | 5.29b             | 462.15                  | 329.15bc               |
| 8  | 450 NPK 15:15:15 + 250 urea                   | 17.76 ab        | 5.21b             | 484.38                  | 369.30a                |
| 9  | 450 NPK 20:10:10 + 250 urea                   | 17.36abc        | 5.14b             | 465.52                  | 353.35ab               |
| 10 | 450 NPK 15:8:10 + 250 urea                    | 17.13abc        | 5.31b             | 466.87                  | 351.63ab               |
| 11 | 450 NPK 15:8:10 micronutrient + 250 urea      | 17.43abc        | 6.82a             | 459.92                  | 354.63ab               |
| 12 | 450 NPK 15:8:10 micronutrient * + 250 urea    | 16.65bc         | 5.28b             | 464.12                  | 349.76abc              |

Average 17.13 5.38 464.79 349.03

CV (%) 3.89 13.10 3.84 4.30

Noted: Numbers followed by different letters in the same column indicate significant differences in Duncan's test at the 5% level.

3.1.4. Grain yield, harvest index, and effectiveness of NPK fertilizer
The application of compound fertilizer NPK 15:15:15 as much as 450 kg/ha combined with urea 250 gave a significantly higher grain yield than the control treatment and standard fertilization, while other NPK fertilizers were not significantly different. Applying NPK 15:15:15 compound fertilizer as much as 450 kg/ha combined with 250 urea was also significantly higher than other NPK fertilization. NPK 15:15:15 fertilization as much as 450 kg/ha combined with 250 urea gave grain yield 12.13 t/ha, control treatment (400 kg urea) and standard (Urea 400+SP36 150 +KCl 112.5 kg/ha) respectively 10.57 t/ha and 10.89 t/ha, while the other NPK treatments produced 10.50 – 11.11 t/ha grain yield.

NPK-compound fertilization at the dose of NPK 350 kg/ha combined with urea 200 kg/ha or with NPK 450 kg/ha combined with urea 250 kg/ha was not significantly different with control (urea 400 kg/ha) on the harvest index. The harvest index at a dose of 350 kg/ha NPK combined with 200 kg/ha urea was 0.30 – 0.31. The NPK treatment of 450 kg/ha combined with urea 250 kg/ha had a harvest index of 0.30 – 0.33 while the control (urea 400 kg/ha) and standard (Urea 400+SP36 150 + KCl 112.5 kg/ha) had a harvest index. 0.31 and 0.30 respectively.
Compound fertilization in all treatments 450 NPK + 250 kg/ha, and 350 NPK 15:15:15 + 200 urea kg/ha, 350 NPK 20:10:10 + 200 urea kg/ha had an RAE value of 124 – 491%. The highest RAE value was obtained at fertilization with 450 NPK 15:15:15 + 250 kg urea (491%).

Table 6. The grain yield, harvest index, and effectivity of NPK fertilizer in research of effectivity of NPK-Compound fertilizer on maize, 2020.

| No | Treatment | Grain yield (t/ha) | Harvest index | RAE (%) |
|----|-----------|--------------------|---------------|---------|
| 1  | 400 Urea (Control) | 10.57b | 0.31tn | - |
| 2  | 400 Urea + 150 SP36 + 112.5 KCl (Standard) | 10.89b | 0.30 | 100 |
| 3  | 350 NPK 15:15:15 + 200 urea | 11.11b | 0.29 | 169 |
| 4  | 350 NPK 20:10:10 + 200 urea | 11.03b | 0.3 | 144 |
| 5  | 350 NPK 15:8:10+ 200 urea | 10.69b | 0.31 | 38 |
| 6  | 350 NPK 15:8:10 micronutrient + 200 urea | 10.77b | 0.31 | 62 |
| 7  | 350 NPK 15:8:10 micronutrient * + 200 urea | 10.50b | 0.30 | -24 |
| 8  | 450 NPK 15:15:15 + 250 urea | 12.13a | 0.30 | 491 |
| 9  | 450 NPK 20:10:10 + 250 urea | 11.11b | 0.32 | 169 |
| 10 | 450 NPK 15:8:10+ 250 urea | 10.96b | 0.30 | 124 |
| 11 | 450 NPK 15:8:10 micronutrient + 250 urea | 11.06b | 0.31 | 154 |
| 12 | 450 NPK 15:8:10 micronutrient * + 250 urea | 11.05b | 0.33 | 150 |
|    | Average   | 10.99 | 0.31 | 131.00 |
|    | CV(%)     | 3.80  | 6.80 |  

Noted: Numbers followed by different letters in the same column indicate significant differences in Duncan’s test at the 5% level.

3.1.5. Economic analysis

The farming analysis was carried out by calculating expenditures consisting of labor and inputs cost (seed, fertilizers, and insecticides/herbicides) and income, which refers to prices at the farm level at the time of the study (prices without subsidies). The price of seed was Rp. 85.000/kg, urea fertilizer was Rp. 6.000/kg, SP-36 was Rp. 6.000/kg, KCl was Rp. 9000/kg, while the price of NPK 15-15-15 fertilizer was Rp. 5.400/kg, NPK 20:10:10 was Rp. 5.517/kg, and NPK 15:8:10 for Rp. 5025/kg while the price of grain yield with a moisture content of 15% was Rp. 3.500/kg.

All treatments of NPK compound fertilization had higher benefits than standard fertilization (Urea 400+SP36 150 +KCl 112.5 kg/ha). Compound fertilization of 350 kg NPK + 200 kg urea/ha gave a profit of Rp. 23.781.000 – 25.668.000 with a B-C ratio value of 1.84-1.94, at a dose of 450 NPK + 250 urea kg/ha giving a profit of Rp. 24.546.000 – 28.041.000 with a B-C ratio of 1.77-1.95, while standard fertilization has a profit of Rp. 23.760.000 with a B-C ratio of 1.66. The highest profit (Rp. 28.041.000 was obtained at 450 NPK 15:15:15 fertilization + 250 kg urea.
Table 7. The farming analysis of NPK compound fertilization on maize plants.

| No | Treatment                                    | Spending (Rp×1000) | Income (Rp.x1000) | Profit (Rp.x1000) | B/C |
|----|---------------------------------------------|--------------------|-------------------|------------------|-----|
|    |                                             | Labor cost         | Production cost*  |                  |     |
| 1  | 400 Urea (Control)                          | 8.15               | 4.18              | 37.00            | 24.68| 2.00 |
|    | 400 Urea + 150                               | 8.26               | 6.09              | 38.11            | 23.76| 1.66 |
| 2  | SP36 + 112.5 KCl (Standard)                 | 8.34               | 4.87              | 38.87            | 25.67| 1.94 |
| 3  | 350 NPK 15:15:15 + 200 urea                 | 8.31               | 4.91              | 38.59            | 25.38| 1.92 |
| 4  | 350 NPK 20:10:10 + 200 urea                 | 8.19               | 4.73              | 37.42            | 24.45| 1.90 |
| 5  | 350 NPK 15:8:10 + 200 urea                  | 8.23               | 4.83              | 37.692           | 24.64| 1.89 |
| 6  | micronutrient + 200 urea                    | 8.12               | 4.83              | 36.73            | 23.78| 1.84 |
|    | 350 NPK 15:8:10 mikkronutrient* + 200 urea  | 8.69               | 5.71              | 42.44            | 28.04| 1.95 |
| 8  | 450 NPK 15:15:15 + 250 urea                 | 8.34               | 5.76              | 38.87            | 24.778| 1.76 |
| 9  | 450 NPK 20:10:10 + 250 urea                 | 8.29               | 5.54              | 38.37            | 24.55| 1.78 |
| 10 | 450 NPK 15:8:10 + 250 urea                  | 8.32               | 5.66              | 38.71            | 24.73| 1.77 |
| 11 | micronutrient + 250 urea                    | 8.32               | 5.66              | 38.66            | 24.68| 1.77 |
| 12 | mikkronutrient* + 250 urea                  | 8.32               | 5.66              | 38.66            | 24.68| 1.77 |

Noted: The costs of harvest and processing were taken by 10% from yield.

3.2. Discussion

The high level of soil fertility is indicated by very high P content and base saturation, as well as high potential K and CEC (Table 3). This causes the application of NPK compound fertilizers to show no significant difference with the application of standard fertilizers (Urea 400+SP36 150 +KCl 112.5 kg/ha) and with control fertilization (urea 400 kg/ha) on growth and seed yield, except for the application of compound fertilizers. NPK 15:15:15 at a dose of 450 kg+Urea 250 kg/ha. The availability of K nutrients in the soil was classified as high, it was not necessary to apply K fertilizer to maize plants, but the maximum yields obtained are 9.03 t/ha and 2.5 t/ha, respectively [9]; [10]. Maize production up to >10 t/ha on soils with high availability of K nutrients can be obtained if fertilizing with a fertilizer dose of 30 – 60 kg K₂O/ha [2]. The study results of Akil in 2018 [11] show that to get grain yield up to >10 t/ha requires potassium 20-60 kg K₂O/ha.

On Inceptisol soils in Bontonompo (Gowa, South Sulawesi) at high P inthe soil (44.4 ppm Bray II) without P could produce 10.51 t/ha in the season I and 8.01 t/ha in season II, but fertilization with 36 kg of P₂O₅ grain yield increasing in the first crop to 11.03 t/ha and the second crop to 10.04 t/ha [12].
Similar to this study, despite the high levels of P and K in the soil, there was a relative increase in yield for all of NPK compound fertilizers. At 350 kg NPK + 200 urea kg/ha it can produce 10.9 – 11.11 t/ha (an increase of 1.14 – 5.05%), and 450 NPK + 250 urea kg/ha was 10.96 – 12.13 t/ha (increase 4.48 – 14.9%) compared to control fertilization /Urea 400 kg/ha (10.57 t/ha). This shows that even though the nutrient content, especially P and K in the soil was high, it still requires additional P and K fertilizer if the yield target was > 10.5 t/ha. Therefore, farmers not only fertilization with using urea, but still need to add fertilizers containing P and K nutrients, such as using NPK compound fertilizers.

Fertilization with 450 NPK 15:15:15 + 250 kg urea gave seed yield, RAE, relatively higher profit than other NPK compound fertilization. NPK compound fertilization in rice showed that 15:15:15 NPK fertilization gave higher yields and was more effective (RAE value) compared to the 20:10:10 formula [13]. Application of compound fertilizer 300 NPK 15-15-15 + urea 250 kg/ha on maize in incertisol soil with low organic matter and N content, high P and low K can produce 6.05 t/ha [14]. NPK 16:16:15 compound fertilizer is effective in increasing plant growth and grain yield, a dose of 450 kg/ha combined with 100 kg urea/ha produces 9.0 tons/ha and an RAE value of about 95.12% equivalent to N, P, K standard fertilization [15]. Application of compound fertilizer 300 NPK + 250 kg/ha on maize in inceptisol soil with low organic matter and N content, high P and low K can produce 6.05 t/ha [14]. NPK 15:15:15 compound fertilizer is subsidized fertilizer, so its availability is often a problem (less available and relatively expensive). Therefore, to ensure that maize productivity remains high, farmers still have to use NPK 15:15:15 compound fertilizer.
4. Conclusion

- High levels of P and K nutrients in the soil still need additional fertilizer containing P and K nutrients for maize if the grain yield is targeted to be >10 t/ha.
- In general, all formulations of NPK compound fertilizers (15:15:15, 20:10:10, and 15:8:10) deserve to be recommended for maize because they provide higher yields and profits than standard single fertilizers.
- Formulation of compound fertilizer NPK 15:15:15 gave the best results. If compound fertilizer NPK -15:15:15 was not available, therefore compound fertilizer NPK-20:10:10 or NPK-15:8:10 can be an alternative because the yields obtained are also relatively high.
- The recommendation for NPK 15:15:15 fertilization on maize was 450 kg/ha combined with 250 kg urea/ha with a yield probability of 12 t/ha.
- The recommendation for 20:10:10 NPK fertilization on maize was 350 kg/ha + 200 kg urea with a yield probability of ±11 t/ha, but if the target yield is 12 t/ha it is recommended to use a dose of 675 kg/ha +100 kg urea/ha.
- The recommendation for 15:8:10 NPK fertilization for maize was 450 kg/ha combined with 250 kg urea/ha with a yield probability of 11 t/ha, but if the target yield is 12 t/ha then the recommended dose is 675 kg/ha + 175 kg Urea/ha.
- Application of 15:8:10 NPK compound fertilizer on soil with pH <6.5 does not need to be combined with micronutrients.

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