The effect of NPK 15-15-6-4 compound fertilizer on corn growth and yield

Andi Faisal Sudding1, Maintang1, Muh Asri1, Abdul Wahid Rauf1, Amiruddin Syam1, and A. Adriani W2*
1Assessment Institute for Agricultural Technology South Sulawesi, Indonesian Agency for Agricultural Research and Development, Makassar, Indonesia
2Lecturer and Researcher, Maros Muslim University, South Sulawesi, Indonesia
Email: andiadrianiwahditiya@gmail.com

Abstract. The availability of NPK compound fertilizer is expected to help farmers to optimally supply the nutrient needs of corn plants. The aim of the study was to determine the efficient dose of NPK 15-15-6-4 fertilizer and its combination with urea on the growth and yield of corn. The study was conducted in Simbang Village, Simbang District, Maros Regency, South Sulawesi in January - April 2019. The study used a Randomized Complete Block Design (RCBD) with a combination of 7 treatments with four replications, consisting of: (P1) 400 kg NPK 15-15-6-4; (P2) 400 kg NPK 15-15-6-4 + 100 kg urea; (P3) 400 kg NPK 15-15-6-4 + 150 kg urea; (P4) 450 kg NPK 15-15-6-4; (P5) 350 kg NPK 15-15-6-4; (P6) 350 kg NPK 15-15-6-4 + 150 kg urea; (P7) 150 kg NPK Phonska + 250 kg urea. The results showed that NPK 15-15-6-4 compound fertilizer had a good effect on the growth and yield of corn plants. NPK 15-15-6-4 compound fertilizer at a dose of 450 kg/ha and a dose of 400 kg NPK 15-15-6-4 + 100 kg urea gave the best effect with total yield up to 5.5-5.9 ton/ha.

1. Introduction
Corn is a cereal commodity that has high economic value. The role of corn other than as food and feed, is now widely used as energy and other industrial raw materials which the demand always continues to increase every year. Therefore, the opportunity to increase domestic corn production is still widely open, by increasing productivity and by expanding the planting area [3].

The demand of corn for the feed industry continues to increase every year in line with the rapid development of the livestock industry [12]. During the period of 2001-2006, the demand of corn for animal feed, food, and beverage industries continued to increase by around 10-15%/year [19]. In 2010, the total demand of feed for the livestock population was 6.99 million tons and the production of feed industry reached 9.36 million tons. For 2020, it is predicted that feed requirements based on the livestock population approach will be 13.36 million tons and the projected feed production from feed industry will reach 18.64 million tons [13]. The increasing demand of corn requires a program to increase the yield, including support for superior varieties and nutrient management through the use of appropriate fertilizers in accordance with plant needs.

The use of urea fertilizer in some sites of corn production is quite high. In South Sulawesi the use of urea fertilizer is around 500 kg/ha, while in East Java it can reach 750 kg/ha [16]. On the other hand, only a few farmers use P and K fertilizers, although the supply of P and K nutrients from the soil 

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is not sufficient for optimal growth of corn plants. This is due to lack of attention to the availability of P and K fertilizers and their relatively expensive prices.

The availability of NPK compound fertilizers in the corn production area is expected to help farmers to use fertilizers in accordance with plant needs. NPK compound fertilizer contains more than one type of nutrient, mainly the N, P and K nutrients. The N, P and K nutrients are one of the essential nutrients that plants need. These nutrients must always be available for corn and other plants in general because they have an important role in the metabolic and biochemical processes of plant cells [8]. In addition to the completeness of nutrient content, the use of compound fertilizers is more homogeneous in the distribution of fertilizers and is simpler because farmers no longer need to mix fertilizers of various types as farmers do when using single fertilizers. The use of compound fertilizers containing N, P and K elements, including NPK Pelangi 15-15-6-4 is expected to increase the productivity of corn plants.

This study aims to determine the optimal dose of NPK 15-15-6-4 fertilizer and its combination with urea and increase the productivity of corn.

2. Materials and Methods

The research was conducted in Simbang Village, Simbang District, Maros Regency, South Sulawesi in January - April 2019.

The materials used are corn seeds (variety: NASA 29), urea (46% N), NPK Phonska fertilizer (15% N, 15%P₂O₅, 15%K₂O, 10% S), NPK 15-15-6-4 compound fertilizer (15% N, 15%P₂O₅, 6%K₂O, 4% MgO), herbicides: Calaris 550 SC (Atrazine 500 g/L, Mesotrione 50 g/L), and pesticides: Furadan 3G (carbofuran 3%), Ridomil 35 SD (Metalaxyl 35%).

The study was using RCBD (Randomized Complete Block Design) with the combination of 7 treatments with four replications (Table 1).

| No. | Treatment | Symbol | Fertilizer dose (kg ha⁻¹) |
|-----|-----------|--------|--------------------------|
|     | NPK 15-15-6-4 (Recommendation) | P1     | NPK 15-15-6-4 | Urea | NPK Phonska |
| 1   | NPK 15-15-6-4 + Urea | P2     | 400          | 100  | 0            |
| 2   | NPK 15-15-6-4 + Urea | P3     | 400          | 150  | 0            |
| 3   | NPK 15-15-6-4 | P4     | 450          | 0    | 0            |
| 4   | NPK 15-15-6-4 | P5     | 350          | 0    | 0            |
| 5   | NPK 15-15-6-4 + Urea | P6     | 350          | 150  | 0            |
| 6   | NPK Phonska + Urea | P7     | 0           | 250  | 150          |

Before planting, corn seeds were first soaked in a solution of Ridomil 35 SD to prevent downy mildew, with a formulation of 5 g of Ridomil in 7.5 ml of water for every kg of corn seed. Planting was carried out with a spacing of 70 x 20 cm (1 seed/hole), the depth of the hole was 3 cm, then the hole was covered with loose soil.

NPK compound fertilizer was given 2 times, each dose at the time of planting and when the plants were 20 days after planting (DAP). The application of fertilizer by digging 5 cm next to the corn plant. Implementation of fertilizer based on the treatment that has been determined in Table 1. During the study, it was relatively free from pests and diseases. Harvesting is done when the cob husks have dried or are brown, the seeds have hardened, and a black layer of at least 50% has formed on each row of seeds. Harvest conducted manually by turning the cobs with the husks or by breaking the stalks of the corn.

The variables observed in this experiment were (1) plant height, (cm), (2) number of leaves, (3) cob height, (4) stem diameter, (5) leaf area, (6) cob length, (7) cob diameter, (8) number of rows per
cobs, (9) number of seeds per row, (10) yield, (11) seed moisture content at harvest, (12) weight of 1000 seeds, (13) weight of fresh-peeled cobs (kg), and (14) yield (ton of seeds/ha).

The data obtained were analyzed for variance (analysis of variance). If the F-test shows a significant effect of fertilization, then the follow-up test will use the DMRT (Duncan Multiple Range Test) 5% test.

3. Results and Discussion

3.1. Plant Growth

The application of NPK 15-15-6-4 compound fertilizer at various doses did not show significant differences in plant height that are observed at 28, 42 and 56 days after planting (DAP). This shows that several doses of both NPK compound fertilizer alone and compound NPK combined with urea have the same effect on corn plant height. The average plant height is presented in Table 2.

Plant height is one of the benchmarks to determine the response of fertilization to the vegetative growth of corn plants. The highest average plant height at 28 DAP was shown by P4 fertilization treatment (84.66 cm), at 42 DAP the highest average plant height was by P7 treatment (138.66 cm) while at 56 DAP the highest average plant height was by P2 and P3 treatments (226.80 cm). The average plant height obtained showed that the corn plants responded relatively well to the given fertilization. There was no difference in plant height by different doses of NPK fertilizer. Apparently, the similar result in plant height is caused by the relatively high nutrient content in the experimental plots that stimulate plant growth. According to [7], Phonska compound fertilizer had no significant effect on plant height of the Lamuru variety of corn in Moodu, Gorontalo City. According to [16] the growth rate of corn plants increases at the age of 3-5 WAP (week after plating), then begins to decline after the age of 5-7 WAP, and continues to decline until the period of 11-13 WAP. If fertilization is done gradually, then the plant must have been fertilized before entering the age of 3-5 WAP, because at that age the plant growth rate is very fast so that the nutrient requirement is very high. The lack of nutrients in this phase can inhibit plant growth. Nutrient requirements of N, P, and K in corn were highest at 35-55 days after planting [10].

Fertilization treatment showed differences in the number of leaves. The average increase in the number of leaves is presented in Table 3. The increase in the number of leaves at the age of 28 DAP was highest in treatments P5 and P6 (7.13 leaves) not significantly different from treatment P4 (6.40 pieces) and significantly different from other treatments (Table 2). At the age of 42 DAP the highest number of leaves was seen in treatment P7 (10.20 leaves) and was not significantly different from other treatments. At the end of the observation, the highest number of leaves was also shown in treatment P7 (11.60 leaves) which was significantly different from treatment P1, P5 and P6. The number of leaves is also a measure of the fertilization response to vegetative growth. Leaves are the main organ where photosynthesis takes place. Therefore, the optimum number of leaves allows a more even distribution of light between leaves. More leaves allow more fertilizer to stick to the leaves, as well as more optimum nutrient absorption.

| Table 2. Effect of NPK 15-15-6-4 and NPK 15-15-6-4 + urea fertilization on corn plant height. |
|----------------------------------|-----------------|-----------------|-----------------|
| Treatment                        | Code | 28 DAP | 42 DAP | 56 DAP |
|----------------------------------|------|--------|--------|--------|
| 400 kg NPK 15-15-6-4 (Recommendation) | P1   | 79.26 a | 143.46 a | 205.13 a |
| 400 kg NPK 15-15-6-4 + 100 kg Urea | P2   | 82.66 a | 151.00 a | 226.80 a |
| 400 kg NPK 15-15-6-4 + 150 Urea   | P3   | 82.66 a | 147.86 a | 226.80 a |
| 450 kg NPK 15-15-6-4              | P4   | 84.66 a | 144.86 a | 223.46 a |
| 350 kg NPK 15-15-6-4              | P5   | 82.00 a | 140.06 a | 216.40 a |
| 350 kg NPK 15-15-6-4 + 150 kg Urea| P6   | 80.00 a | 138.66 a | 210.26 a |
| 250 kg Urea + 150 NPK Phonska     | P7   | 83.33 a | 152.13 a | 217.80 a |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.
### Table 3. Effect of fertilization combination (NPK 15-15-6-4 and NPK 15-15-6-4 + urea) on the number of leaves of corn plants.

| Treatment                                      | Code | 28 DAP | 42 DAP | 56 DAP |
|------------------------------------------------|------|--------|--------|--------|
| 400 kg NPK 15-15-6-4 (Recommendation)        | P1   | 5.73   | 9.60   | 10.60  |
| 400 kg NPK 15-15-6-4 + 100 kg Urea           | P2   | 6.13   | 9.86   | 11.40  |
| 400 kg NPK 15-15-6-4 + 150 Urea              | P3   | 6.20   | 9.66   | 11.00  |
| 450 kg NPK 15-15-6-4                         | P4   | 6.40   | 9.46   | 11.00  |
| 350 kg NPK 15-15-6-4                         | P5   | 7.13   | 9.53   | 10.53  |
| 350 kg NPK 15-15-6-4 + 150 kg Urea           | P6   | 6.0    | 9.26   | 10.60  |
| 250 kg Urea + 150 NPK Phonska                | P7   | 7.13   | 10.20  | 11.60  |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.

### 3.2. Total Yield and Yield components of corn (ton/ha)

Yield components such as cob length, cob diameter, and seed yield determine the total yield obtained. This is because the diameter of the cob affects the number of rows of seeds on the cob, the length of the cob affects the number of seeds per row, while the high number of seeds indicates that the partition of assimilates to seeds is greater than to other parts of the organ such as the cob. According to [9], varieties with longer cobs have the opportunity to give higher yields. The cob length indicates the density of seeds and is closely related to the number of seeds per cob.

### Table 4. Effect of fertilization combination (NPK 15-15-6-4 and NPK 15-15-6-4 + urea) on the length and diameter of corn cobs.

| Treatment                                      | Code | Cob Length (cm) | Cob Diameter (mm) |
|------------------------------------------------|------|-----------------|-------------------|
| 400 kg NPK 15-15-6-4 (Recommendation)        | P1   | 15.46 ab        | 45.09 a           |
| 400 kg NPK 15-15-6-4 + 100 kg Urea           | P2   | 17.40 a         | 46.48 a           |
| 400 kg NPK 15-15-6-4 + 150 Urea              | P3   | 15.70 ab        | 44.73 a           |
| 450 kg NPK 15-15-6-4                         | P4   | 14.20 b         | 44.97 a           |
| 350 kg NPK 15-15-6-4                         | P5   | 14.26 b         | 45.12 a           |
| 350 kg NPK 15-15-6-4 + 150 kg Urea           | P6   | 14.23 b         | 41.70 b           |
| 250 kg Urea + 150 NPK Phonska                | P7   | 15.70 ab        | 44.73 ab          |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.

The treatments of NPK 15-15-6-4 (P1, P4, P5) and NPK 15-15-6-4 + Urea (P2, P3, P6) showed different responses to the yield components of cob length, cob diameter, number of rows per cob, and number of seeds per row (Table 4 and Table 5). Treatment P2 (400 kg NPK 15-15-6-4 + 100 kg Urea) showed better cob length (17.4 cm), which is not significantly different from treatments P1, P3, and P7 and significantly different from P4, P5, and P6. The diameter of the cob was also the best in treatment P2 (46.48 cm) which is significantly different from treatment P6 and not significantly different from other fertilization treatments (Table 4).

The number of rows per cob also appeared to be higher in treatment P2 and P5 (17.73) and significantly different from treatment P7 (12.33) (Table 5). Observation of the number of seeds per row also appeared to be higher in treatment P2 (37.20 seeds) which is not significantly different from treatments P7 and P3 and significantly different from other treatments. The NPK 15-15-6-4 treatment did not show any significant difference to other yield components, namely yield (Table 5), seed moisture content, and weight of 1000 seeds (Table 6), weight of fresh-peeled cobs, and seed yield (ton/ha) (Table 7). The highest seed yield was obtained in the fertilization treatment NPK 15-15-6-4 with the dose of 450 kg/ha (P4) which was 5.9 ton/ha, followed by treatments P7 (5.6 ton/ha) and P2 (5.5 ton/ha). Other treatments also showed results that are not significantly different, ranging from 5.1
The lowest yield (4.6 ton/ha) was shown by treatment P1 (NPK 15-15-6-4 based on the recommendation of 400 kg/ha).

### Table 5. Effect of fertilization combination (NPK 15-15-6-4 and NPK 15-15-6-4 + urea) on the number of rows per cob, number of seeds per row, and yield of corn plants.

| Treatment Code | Number of Rows | Number of Seeds | Yield |
|----------------|----------------|----------------|-------|
| P1 400 kg NPK 15-15-6-4 (Recommendation) | 12,93 ab | 32,0 bc | 0,7 a |
| P2 400 kg NPK 15-15-6-4 + 100 kg Urea | 13,73 a | 37,20 a | 0,7 a |
| P3 400 kg NPK 15-15-6-4 + 150 Urea | 12,86 ab | 37,32 abc | 0,7 a |
| P4 450 kg NPK 15-15-6-4 | 13,06 ab | 31,0 bc | 0,7 a |
| P5 350 kg NPK 15-15-6-4 + 150 kg Urea | 12,80 ab | 30,40 c | 0,7 a |
| P6 250 kg Urea + 150 NPK Phonska | 12,33 b | 35,93 ab | 0,7 a |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.

### Table 6. Effect of fertilization combination (NPK 15-15-6-4 and NPK 15-15-6-4 + urea) on moisture content and weight of 1000 seeds.

| Treatment Code | Moisture Content | 1000 Seeds (gr) |
|----------------|-----------------|-----------------|
| P1 400 kg NPK 15-15-6-4 (Recommendation) | 30,6 a | 394,33 a |
| P2 400 kg NPK 15-15-6-4 + 100 kg Urea | 29,4 a | 382,67 a |
| P3 400 kg NPK 15-15-6-4 + 150 Urea | 29,3 a | 389,0 a |
| P4 450 kg NPK 15-15-6-4 | 30,3 a | 383,33 a |
| P5 350 kg NPK 15-15-6-4 | 30,5 a | 383,0 a |
| P6 350 kg NPK 15-15-6-4 + 150 kg Urea | 30,8 a | 354,67 a |
| P7 250 kg Urea + 150 NPK Phonska | 29,6 a | 391,33 a |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.

### Table 7. Effect of fertilization combination (NPK 15-15-6-4 and NPK 15-15-6-4 + urea) on the weight of fresh-peeled cobs and corn seed yield (ton/ha).

| Treatment Code | Weight of Fresh-Peeled Cobs | Yield (ton/ha) |
|----------------|----------------------------|---------------|
| P1 400 kg NPK 15-15-6-4 (Recommendation) | 4,67 a | 4,6 a |
| P2 400 kg NPK 15-15-6-4 + 100 kg Urea | 5,33 a | 5,5 a |
| P3 400 kg NPK 15-15-6-4 + 150 Urea | 5,0 a | 5,1 a |
| P4 450 kg NPK 15-15-6-4 | 5,67 a | 5,9 a |
| P5 350 kg NPK 15-15-6-4 | 5,17 a | 5,2 a |
| P6 350 kg NPK 15-15-6-4 + 150 kg Urea | 5,5 a | 5,3 a |
| P7 250 kg Urea + 150 NPK Phonska | 5,5 a | 5,6 a |

Note: numbers followed by the same letter are not significantly different in Duncan's 5% test.

In general, the yield obtained is still low compared to the genetic potential of this corn variety, where NASA 29 hybrid corn can reach 13.50 ton/ha and the average yield is 11.93 ton/ha. It is suspected that corn production can still be increased through the application of a higher dose of NPK 15-15-6-4 or a combination of NPK 15-15-6-4 and urea. This is in line with the opinion of [18] that NPK fertilizer can increases the dry weight of corn. To achieve a nutrient balance, NPK still needs to be added to a single fertilizer, especially a source of N nutrients. The results of research by [6] in North Luwu district showed that the application of fertilizer at a dose of 600 kg/ha Phonska (90 kg N, 90 kg P2O5, 90 kg K2O) or equivalent to a dose of 200 kg/ha Urea, 250 kg/ha SP36 and 150 kg/ha KCl...
gave the highest production of 7.22 ton/ha. According to [16], based on the results of research on inceptisol soils in Gowa district, it is recommended that NPK 20-10-10 should be applied once and followed by the application of 100 kg urea/ha. If there is capital limitation, farmer can choose a combination with lower production cost. The cheapest is 300 kg of compound NPK 20-10-10 given once and combined with 100-200 kg urea/ha. However, based on the results of the research by [11], it was shown that the NPK dose of 300 kg/ha was optimum for the growth and yield of hybrid corn with a yield of 8.92 tons. A study by [14] added that NPK fertilizers of less than 300 kg/ha have low yields when compared to doses of 300 kg/ha. The result from [1] showed that on dry land in Parigi sub-district, Muna, Southeast Sulawesi, fertilization of 200 kg Urea/ha + 300 kg NPK Phonska/ha had the highest yield and yield component of 7.33 ton/ha. A study by [4], stated that the application of NPK increased the stem diameter of corn plants aged 2 WAP, 4 WAP, and 6 WAP. The result from [2] stated that corn yields increased with the use of NPK fertilizer.

NPK compound fertilizer releases nutrients gradually so that it can be absorbed by plants in accordance with plant needs. The functions of N, P, and K are closely related in supporting the photosynthetic process and the output of photosynthetic process, as well as increasing plant growth through the mechanism of converting NPK nutrients into organic compounds or energy through metabolism. An essential nutrient cannot be replaced by other nutrients so only with essential nutrients plants can fulfill their life cycle.

NPK has essential function in plant growth, as a component of enzyme molecules and chlorophyll molecules, which play an important role in the energy transfer process in cells and in the process of transforming photosynthetic into simple molecules that are rearranged into molecules of other materials needed in plant cell metabolism processes [5]. Nitrogen (N) as an ingredient of leaf chlorophyll is required to stimulate the photosynthesis process in leaves. In addition, N is also a constituent of amino acids and proteins for plant growth. Phosphate (P) is required for growth and generating energy (ATP) including the formation of seeds, while K stimulates the translocation of photosynthetic products from leaves to other parts of the plant and plays a role in the synthesis of carbohydrates, therefore the seed yield in 400 kg/ha NPK treatments combined with 200 kg/ha urea can reach the yield of 10 ton/ha dry grain [16]. Phosphate is required for plant maturation and root growth, while Kalium is a building block for cell walls, regulates the opening and closing of guard cells in stomata, and determine the stem strength of plants as well as resistance to disease attack [15]. If these three nutrients are not available, poorly available, or available but not in balance, plant growth and development will be hampered.

In corn plants, the pattern of nutrient uptake in one season follows the dry matter accumulation pattern as described by [10]. Little N, P, and K are absorbed by plants in the vegetative phase of growth, and nutrient uptake is very fast during the generative phase and seed filling. The elements N and P are continuously absorbed by plants until they are near maturity, while K is mainly needed when silking. Most of N and P are carried to the growing points, stems, leaves, and male flowers, and then transferred to seeds. As much as 2/3-3/4 of the element K is left in the stem. Thus, nutrients N and P are taken from the soil by seeds at harvest, while K is taken by stover. Returning corn stover waste to soil is very important as it will give the Kalium back to the soil. According to [17], the availability of nutrients is related to the seed filling process. Nutrients that are absorbed will be accumulated in the leaves into proteins that will form seeds. The accumulation of metabolic products during the formation of seeds will increase, so that the seeds will have a maximum size and weight. This occurs when the nutrient needs are fulfilled which stimulates the metabolism to run optimally.

4. Conclusion

NPK 15-15-6-4 had a good effect on the growth and yield of corn plants. NPK 15-15-6-4 at a dose of 450 kg/ha and a dose of 400 kg NPK 15-15-6-4 + 100 kg urea gave the optimal effect with production reached 5.5-5.9 ton/ha.
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