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Growth Rate and Production of Hybrid and Local Maize (*Zea Mays* L.) in Response to Various Doses of Nitrogen Fertilization

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ABSTRACT

*Corn (*Zea mays *L.) is a strategic commodity after rice so that the productivity need to be optimize through nitrogen fertilization. The aim of this research is to evaluate the effect of various doses of urea fertilizer on the growth rate and yield of hybrid corn and local corn. This research was conducted from June to October 2022 on the pilot land of the Agricultural Training Center (Bapeltan), Hajimena, Bandar Lampung. The factorial experiment (5x2) was arranged in a randomized complete block design with 3 replications. The first factor is urea fertilizer doses, namely: 200 kg/ha (N1), 250 kg/ha (N2), 300 kg/ha (N3), 350 kg/ha (N4) and 400 kg/ha (N5), while other fertilizers were given to all experimental plots in the same rate (150 SP-36 kg/ha and 100 kg KCl kg/ha). The second factor is the corn variety, included V1 (BISI-18) and V2 (Tongkol Merah) varieties. The results showed that increasing dose of urea from 200 to 400 kg/ha was not able to increase the growth rate of both corn varieties. The productivity of the BISI-18 corn variety is higher than that of the Tongkol Merah as indicated by the wet weight of the cobs (g), the dry weight of grains per plot (g), and the yield of corn dry grains (tons/ha). The yield of dry corn seeds for the BISI-18 corn variety was 11.7 tons/ha, while for the Tongkol Merah variety was 9.44 tons/ha.*

1. INTRODUCTION

Corn (*Zea mays* L.) is a strategic commodity second only to rice. Apart from being consumed directly as food and livestock feed, corn is used as an industrial raw material, such as alternative fuel (biofuel), polymers, corn oil, and others (Karim *et al*., 2020; Dewanto *et al*., 2013). The low productivity of corn and the increasing demand for corn in the global market have led to a depletion of corn stocks worldwide (Rahmawati, 2017). In Indonesia, corn varieties for seeds are divided into three groups: hybrid corn, composite corn, and local corn. Hybrid corn constitutes the largest percentage of cultivated varieties, accounting for more than 75 percent, composite varieties at 17.29 percent, and local varieties only at 5.84 percent (Astuti *et al*., 2020). Indonesia has land suitable for corn cultivation, providing an opportunity to be a supplier or producer of corn for the world market (Nadhira & Herawaty, 2015). Indonesia ranks 10 of the top corn-producing countries globally (average 2014-2018) (Mutia, 2021).

According to Abera *et al*. (2017), the use of superior varieties with optimal nitrogen fertilizer application practices opens up the potential for high yields. Hybrid corn varieties respond well to nutrient application, especially nitrogen and phosphorus, with high production compared to local varieties under conducive environments and better management practices. Hybrid corn with delayed senescence can utilize nitrogen during the grain-filling period (Aziiba *et al*., 2019).

Nitrogen is essential for plant growth and a major factor limiting crop yields. To achieve high yields, efficient use of nitrogen sources is required to maximize growth and meet the minimum nitrogen needs (Almodares *et al*., 2009). Therefore, appropriate fertilization needs to be determined, where fertilization with the right dosage is one aspect of

obtaining rapid and good plant growth. According to Syafruddin (2015), the nitrogen fertilizer dosage for hybrid corn plants with yield potential of 9-13 t/ha is 160-260 kg/ha for soil with low organic carbon content, 133-233 kg/ha for soil with medium organic carbon content, and 105-205 kg/ha for soil with high organic carbon content.

Corn productivity in Indonesia can be increased with the use of superior varieties and appropriate fertilization. Tobing *et al*. (2022) found that increasing nitrogen dosage up to 270 kg/ha linearly increased total biomass, cob weight, cob weight without husk, cob diameter, grain weight per cob, and grain weight per plot. Gradual application of urea fertilizer can enhance plant growth and ensure the availability of nitrogen in the soil (Lihiang & Lumingkewas, 2020). According to Burns (2006), differences in total nitrogen requirements and plant efficiency in retrieving nitrogen from the soil are influenced by soil factors.

Corn production increases with the application of both inorganic and organic fertilizers (Margaretha, 2015). Wade *et al*. (2020) stated that nitrogen fertilization could double corn yields compared to no fertilization. Nitrogen is a limiting nutrient for the growth of hybrid corn (Akil, 2011). According to Sonbai *et al.* (2013), nitrogen is the primary macronutrient in corn production cultivated in dryland. Muñoz-Huerta *et al*. (2013) stated that crop yields are influenced by the nitrogen status of corn plants. This study aims to evaluate the effect of different urea fertilizer applications on the growth rate of hybrid corn and determine the urea fertilizer dosage that can provide the highest corn yield among the five fertilization dosages.

2. MATERIALS AND METHODS

The study was conducted from June to October 2022. The research was carried out at the demonstration plot of the agricultural training center (Bapeltan) Hajimena, Bandar Lampung (-5°36', 105°22', 47.8 m, 127). Before planting corn seeds, soil samples were taken for chemical analysis. Soil samples were taken at 5 points in the field to a depth of 60 cm. The soil samples from the 5 points were then mixed (composite) and cleaned of debris such as stones, trash, and other objects, then air-dried.

Soil chemical analysis was conducted before and after harvest. The analyzed organic matter content included total nitrogen, phosphorus (P), potassium (K), and soil pH. Total nitrogen analysis was also performed on leaf samples taken from the flag leaf at the maximum vegetative growth stage at 7 weeks after sowing (WAS) and at the final generative stage at 17 WAS. The analysis revealed that the initial soil had pH 6.34 with nutrient content of 0.11% N (Nitrogen), 38.52 mg/kg P (Phosphorus), and 225.42 mg/kg K (Potassium).

2.1. Tools and Materials

The tools used in this study included land preparation tools (four-wheel tractor, rotary plow, two-wheel tractor), tools for making experimental plots (rope, plastic rope, measuring tape, hoe, zinc plates, nails, wood, and crowbar), tools for watering plants (hose, pipes, and sprinklers), tools for pest control (hand sprayer, measuring glass), tools for measuring observation variables (oven, analytical balance, regular scale, caliper, cutter, plastic tarp), laboratory analysis tools, and other supporting tools. The materials used in the study were BISI-18 corn seeds (hybrid variety) and Tongkol Merah corn seeds (local variety), urea fertilizer, SP-36 fertilizer, KCl fertilizer, fungicide Anrin, herbicide Paraquat, insecticide Meurtieur, and other supporting materials.

2.2. Method

This experiment was arranged in a 5 x 2 factorial design using a Completely Randomized Block Design (CRBD) with three replications. The first factor was urea fertilizer treatment, namely: 200 kg/ha urea (N1), 250 kg/ha urea (N2), 300 kg/ha urea (N3), 350 kg/ha urea (N4), and 400 kg/ha urea (N5). The other fertilizers were applied according to recommendations: 150 kg/ha SP-36 and 100 kg/ha KCl. In this study, the fertilization application was the same, with three application times consisting of: (F1) after 2 WAS, (F2) after 5 WAS, and (F3) after 8 WAS. The second factor was corn variety treatment, namely: V1 = BISI-18 variety and V2 = Red Cob variety. The planting distance used was 70 x 20 cm. The experimental layout is shown in Figure 1. Number of plots: 30; plot size: 3 m x 4.9 m, distance between plots: 0.5 m, distance between blocks: 1 m, and distance from the edge: 1 m.

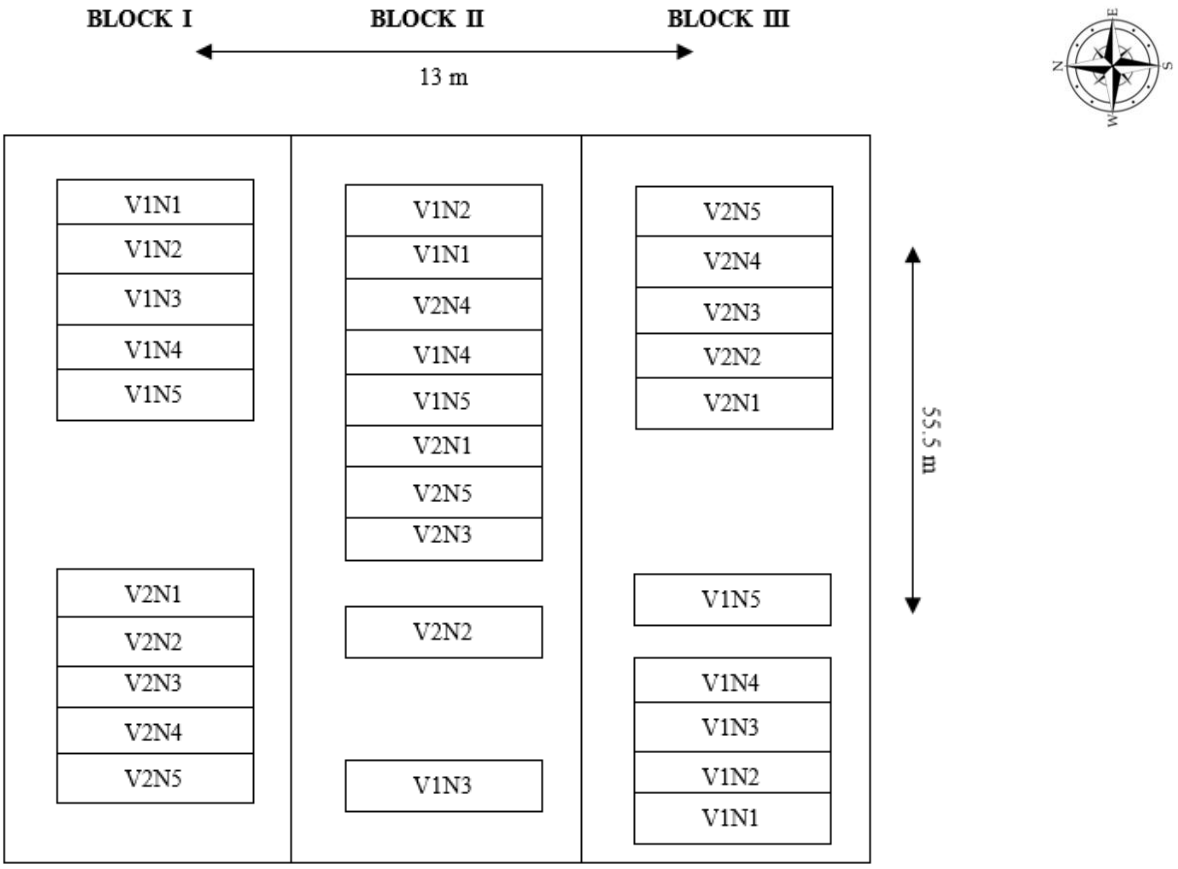

Figure 1. The experimental layout

2.3. Observation Variables

2.3.1 Growth Rate Observation (Destructive Plants)

Observations on destructive plants (two plants) were randomly selected from the experimental plot to monitor the vegetative growth rate until harvest. The average crop growth rate (CGR) is defined as the increase in dry weight per unit time. The calculation of the average growth rate assumes a linear increase in plant growth (Pandey *et al*., 2017). The absolute growth rate was calculated according to Hunt (1989) as follows:

$$CGR = \frac{\Delta W}{\Delta t} = \frac{W_2 - W_1}{t_2 - t_1} \quad (1)$$

where W_2 is data at the second observation age, W_1 is data at the first observation age, t_1 is age of plants at the first observation, and t_2 is age of plants at the second observation. Growth rate observations were conducted at 3, 5, 7, 9, 11, 13, 15, and 17 weeks after sowing (WAS) by cutting the corn plant stems above the soil surface. The growth rate observation variables included: plant height (cm), number of leaves, stem diameter (mm), dry weight of husk, dry weight of stem, dry weight of leaves, and dry weight of seeds.

2.3.2. Harvest Plot Observation

Observations were made at harvest at 17 WAS within the harvest plot, and the observed and measured variables included: number of plants, number of cobs, weight of 100 seeds, cob diameter, fresh weight of cobs, dry weight of seeds per harvest plot (g), and dry shelled seed weight per hectare with the formula:

$$CDS = HP \times \left(\frac{DSW}{plot}\right) \quad (2)$$

where CDS is yield of dry shelled grains weight (ton/ha), DSW is dry grain weight, HP is number of plots in 1 hectare. The area of the harvest plot: 4.9 m x 3 m = 14.7 m², the number of harvest plots: 10000 m² / 14.7 m² = 680.27 plots.

2.4. Evaluation of Nitrogen Use Efficiency (NUE)

Nitrogen use efficiency (NUE) was evaluated using the agronomic nitrogen efficiency parameter according to the formula of (Coelho *et al*., 2022). NUE in this study was used to evaluate the efficiency of applied urea fertilizer on the total nitrogen in the leaf at maximum vegetative and final generative stages. The modified NUE formula was:

$$NUE = \left(\frac{Dry\ weight\ of\ plant\ parts}{Total\ nitrogen\ content\ in\ the\ leaf}\right) \times 100\% \quad (3)$$

where plant parts included leaves, stem, husk, and grains, and total N content in the leaf was measured at maximum vegetative stage and final generative stage.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Growth Rate of Corn Leaf

In general, the growth rate of corn leaves showed an increase and reached a maximum at the age of 5-7 WAS (Figure 2). After that, the growth of the number of leaves appeared to stop and began to decline at the age of 7-9 WAS (Table 1). Entering the age of 3-5 WAS, the growth rate was very fast as seen from the variable number of leaves. This is because at the age of 3-5 WAS the corn plant enters the stage of perfectly open leaves of 5-10 strands (Table 1). The V1N1 treatment produced the lowest growth rate of the number of leaves of 1.75 strands/week, while the V1N3 treatment produced the highest increase in the number of leaves of 2.08 strands/week. Khairiyah *et al.* (2017) reported

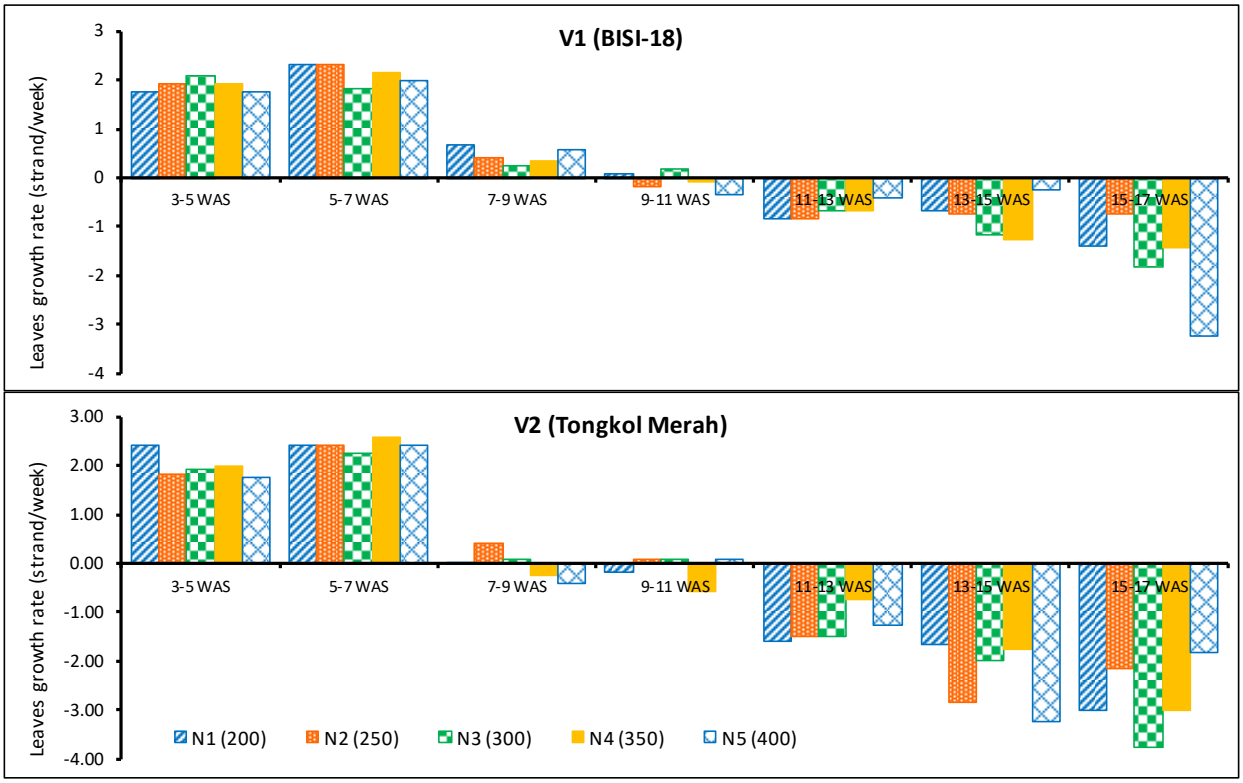

Figure 2. The weekly leaf growth rate of two maize varieties under different fertilizer dosages application

Table 1. Number of leaves of two corn varieties under different urea dosages at 3 to 17 WAS

Treatment	Number of leaves							
	3 WAS	5 WAS	7 WAS	9 WAS	11 WAS	13 WAS	15 WAS	17 WAS
Variety (V)								
BISI-18 (V1)	5.80 a	9.57 a	13.8 a	14.4 a	14.6a	13.2 a	11.6 a	8.13 a
Tongkol Merah (V2)	5.73 a	10.0 a	14.8 a	14.4 a	14.5 a	11.9 b	7.33 b	1.83 b
Urea fertilizer (N)								
Urea 200 kg/ha (N1)	5.42 c	9.58 a	14.3 a	15.1 a	14.9 a	12.5 a	10.2 a	5.75 a
Urea 250 kg/ha (N2)	5.58 bc	9.33 a	14.1 a	14.9 a	14.8 ab	12.5 a	8.92 a	6.00 a
Urea 300 kg/ha (N3)	6.17 a	10.0 a	14.08 a	14.4 a	14.7 ab	12.5 a	9.33 a	3.75 a
Urea 350 kg/ha (N4)	5.75 bc	10.0 a	14.75 a	14.8 a	14.2 b	12.7 a	9.75 a	5.33 a
Urea 400 kg/ha (N5)	5.92 ab	10.0 a	14.42 a	14.6 a	14.3 ab	12.6 a	9.17 a	4.08 a

Note: Mean values followed by the same letter in the same column are not significantly different according to the LSD test at $\alpha = 0.05$.

the growth rate of the number of hybrid corn leaves at the age of 3-4 WAP of 0.66 strands and increased to 1.38 strands at the age of 4-5 WAS. The growth rate of the number of leaves reached a maximum at the age of 5-7 WAS. The V1N1 treatment produced a growth rate of the number of leaves of 2.33 strands/week, higher than the V1N3 treatment which resulted in a decrease in the growth rate of the number of leaves to 1.83 strands/week. Khairiyah *et al.* (2017) reported that the growth rate of the number of hybrid corn leaves at the age of 4-5 WAS was 1.38 strands and decreased to 0.57 strands at the age of 5-6 WAS.

The average number of leaves (Table 1) showed a significant difference due to the variety at the age of 13 to 17 WAS. The BISI-18 variety (V1) produced 13.2 strands of leaves at the age of 13 WAS, then decreased to 11.6 strands (age 15 WAS), and 8.13 strands (age 17 WAS). In the same age period, the number of leaves of the Tongkol Merah variety (V2) was lower and decreased faster than the BISI-18 variety (V1). The decrease in the number of leaves because the corn plant has entered the generative phase and the drying leaves at the base of the stem of the Tongkol Merah variety increased compared to the BISI-18 variety. Mahdiannoor & Istiqomah (2015) stated that the decrease in the number of leaves occurred due to the aging process of the plant which was marked by the drying of the lower leaves of the plant.

The average number of leaves (Table 1) shows significant differences due to urea at 3 and 11 WAS. Treatment with Urea at a dose of 200 kg/ha (N1) resulted in a leaf count of 14.9 leaves, but with an increase in urea to 300 kg/ha (N3), the leaf count decreased to 14.7 leaves at 11 WAS. This comparison of leaf counts at 11 WAS between urea doses of 200 kg/ha (N1) and 300 kg/ha (N3) shows a decrease in leaf count for N3 compared to N1. Tobing *et al*. (2022) stated that the leaf count showed no significant differences due to nitrogen, with 174 kg/ha nitrogen (equivalent to 377 kg/ha urea) resulting in 14.3 leaves at 9 WAS. According to Efendi & Suwardi (2010), a nitrogen dose of 150 kg/ha (equivalent to 326 kg/ha urea) produced 14 leaves/plant, but with an increased nitrogen dose of 225 kg/ha (equivalent to 489 kg/ha urea), the leaf count decreased to 13.5 leaves.

3.1.2. Growth Rate of Corn Plant Height

The growth rate of plant height (Table 2) shows an increase in plant height, reaching a maximum at 7-9 weeks after sowing (WAS). After that, the growth rate stops and declines at 11-13 WAS. The growth rate of plant height began to increase at 3-5 WAS (Figure 3). Treatment V1N1 resulted in a growth rate of 11.4 cm/week, while treatment V1N3 showed an increased growth rate of 14.8 cm/week. Meanwhile, treatment V2N1 produced a growth rate of 21.8 cm/week, while V2N3 showed a decreased growth rate of 17.6 cm/week. According to Khairiyah *et al.* (2017), the growth rate of hybrid corn plant height at 3-4 WAS showed an increase from 7.63 cm at 2-3 WAS to 14.8 cm at 3-4 WAS.

The growth rate of plant height increased and reached its maximum at 5-7 WAS (Figure 3). Treatment V1N1 resulted in a growth rate of 48.5 cm/week, while treatment V1N3 showed an increased growth rate of 51.2 cm/week. Meanwhile, treatment V2N1 produced a growth rate of 58.3 cm/week, while V2N3 showed an increased growth rate of 60.4 cm/week. According to Khairiyah *et al.* (2017), the growth rate of hybrid corn plant height at 5-6 WAS showed a decrease from 15.9 cm at 4-5 WAS to 14.3 cm at 5-6 WAS.

Table 2. Plant height of two corn varieties under different urea dosages at 3 to 17 WAS

Treatment	Plant height (cm)							
	3 WAS	5 WAS	7 WAS	9 WAS	11 WAS	13 WAS	15 WAS	17 WAS
Variety (V)								
BISI-18 (V1)	70.2 b	147 b	228 b	251 b	395 a	243 b	235 b	242 b
Tongkol Merah (V2)	77.2 a	160 a	245 a	274 a	288 a	264 a	271 a	273 a
Urea fertilizer (N)								
Urea 200 kg/ha (N1)	69.9 b	149 a	234 a	262 a	273 a	261 a	252 ab	253 a
Urea 250 kg/ha (N2)	70.5 b	152 a	231 a	260 a	271 a	243 a	249 ab	255 a
Urea 300 kg/ha (N3)	71.5 b	154 a	232 a	267 a	635 a	256 a	268 a	252 a
Urea 350 kg/ha (N4)	77.1ab	155 a	232 a	259 a	264 a	248 a	263 a	258 a
Urea 400 kg/ha (N5)	79.5a	158 a	248 a	263 a	262 a	261 a	234 b	268 a

Note: Average values followed by the same letter in the same column are not significantly different according to the LSD test at $\alpha = 0.05$.

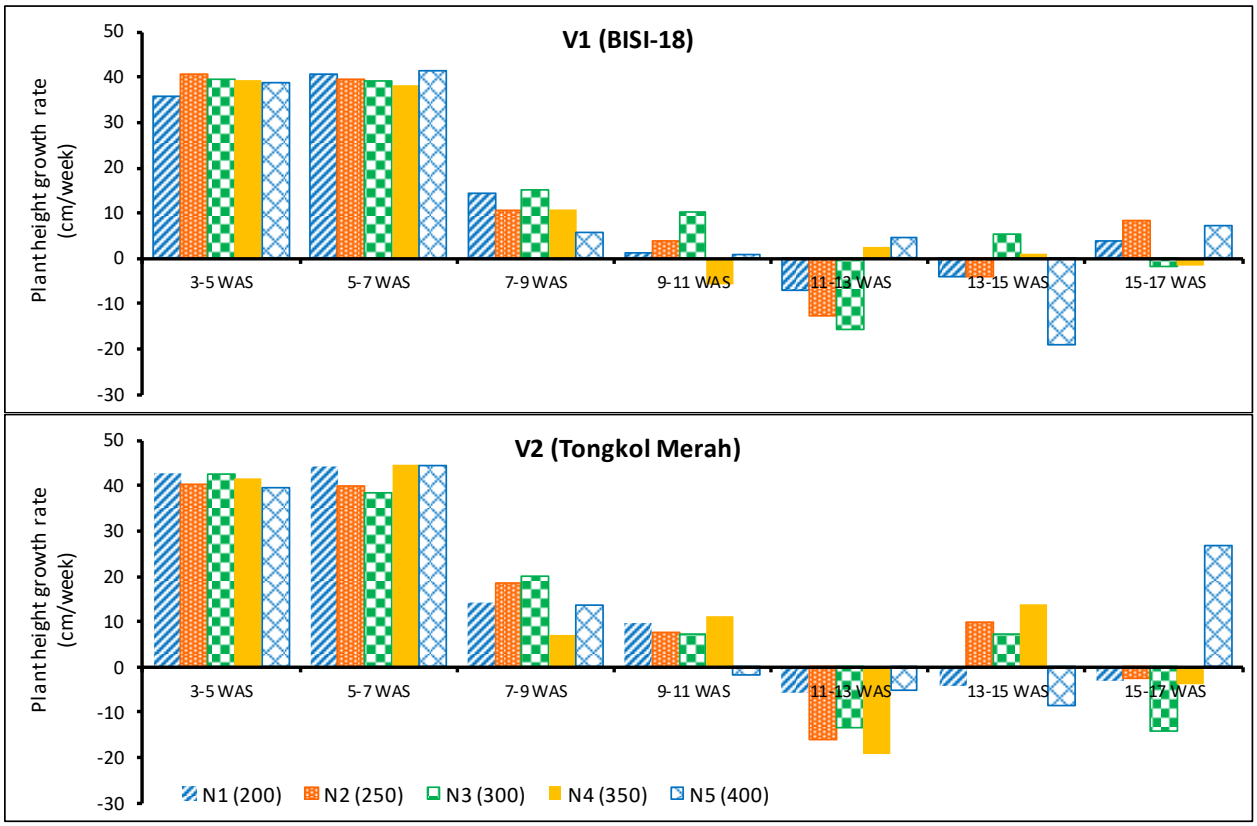

Figure 3. The weekly plant height growth rate of two maize varieties under different fertilizer dosages application

The average plant height (Table 2) showed significant differences due to the variety at 3 to 9 WAS and 13 to 17 WAS. The Tongkol Merah variety (V2) showed an average plant height of 274 cm, higher than the BISI-18 variety (V1), which reached 251 cm at 9 WAS. According to Nurlailah & Setyawan (2019), plant height showed significant differences due to variety, with local varieties reaching a height of 182 cm. Maruapey & Faesal (2010) stated that the height of local corn did not show significant differences and reached 219 cm at 8 WAS.

The average plant height shows significant differences due to urea at 3 and 15 WAS (Table 2). Treatment with urea at a dose of 300 kg/ha (N5) at 15 WAS resulted in a plant height of 268 cm, which decreased to 252 cm with the addition

of urea at 200 kg/ha (N1). Rahmawati (2017) stated that nitrogen dose did not significantly affect plant height, but a nitrogen dose of 150 kg/ha (equivalent to 325 kg/ha urea) resulted in a height of 126 cm, which decreased to 106 cm with a reduction in nitrogen dose to 75 kg/ha (equivalent to 163 kg/ha urea). Different results were reported by Efendi & Suwardi (2010), who stated that plant height increased with a nitrogen dose of 150 kg/ha (equivalent to 325 kg/ha urea), reaching 278 cm, but decreased to 274.57 cm with the addition of nitrogen fertilizer to 225 kg/ha (equivalent to 489 kg/ha urea).

3.1.3. Growth Rate of Corn Stem Diameter

In general, there was an increase in stem diameter from the age of 3 to 7 WAS. The growth rate reached maximum at 3-5 WAS. Then, the growth of stem diameter stopped and declined at 9-11 WAS (Figure 4). The figure shows that growth rate of stem diameter reached maximum at 3-5 WAS. Treatment V1N1 resulted in a stem diameter growth rate of 5.58 mm/week, while treatment V1N3 showed a growth rate of 6.22 mm/week. Meanwhile, treatment V2N1 produced a growth rate of 6.25 mm/week, while V2N3 showed a decreased growth rate of 5.89 mm/week (Figure 4). According to Khairiyah *et al.* (2017), the growth rate of hybrid corn stem diameter reached a maximum of 3.3 mm at 3-4 WAS.

The average stem diameter (Table 3) showed significant differences due to the variety at 11 WAS. The Tongkol Merah variety (V2) showed an average stem diameter of 22.3 mm, higher than the BISI-18 variety (V1), which had an average stem diameter of 19.9 mm. According to Maruapey & Faesal (2010), the average stem diameter showed no significant differences due to variety, with local corn producing an average stem diameter of 22.4 mm. The average stem diameter shows significant differences due to urea at 11 WAS. Treatment with urea at a dose of 400 kg/ha (N5) resulted in an average stem diameter of 22.5 mm, higher than other urea doses (Table 3). Efendi & Suwardi (2010) stated that hybrid corn tends to increase stem diameter growth at a nitrogen dose of 150 kg/ha (equivalent to 326 kg/ha urea) to

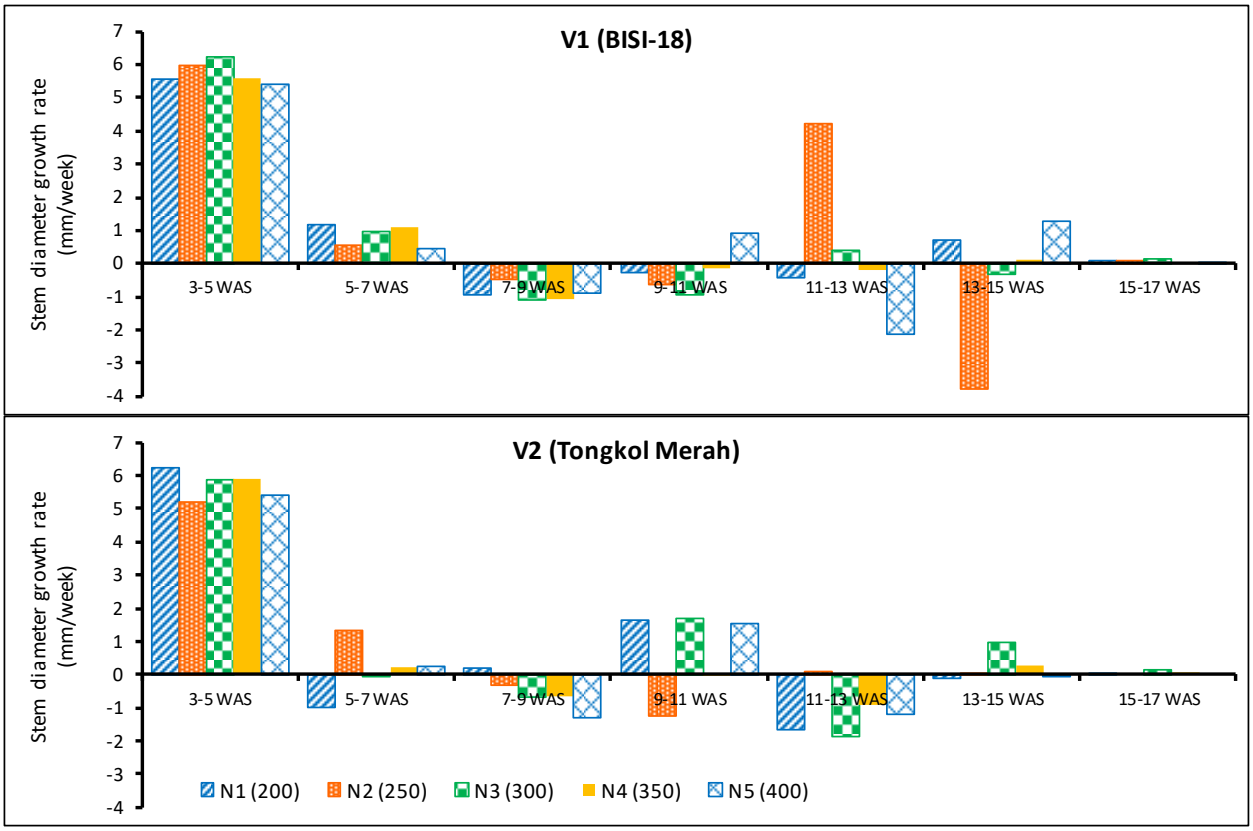

Figure 4. The weekly stem diameter growth rate of two maize varieties under different fertilizer dosages application

Table 3. Stem diameter of two corn varieties under different urea dosages at 3 to 17 WAS

Treatment	Stem diameter at weeks (mm)							
	3 WAS	5 WAS	7 WAS	9 WAS	11 WAS	13 WAS	15 WAS	17 WAS
Variety (V)								
BISI-18 (V1)	8.93 a	20.5 a	22.1a	20.4 a	19.9 b	20.7 a	19.9 a	20.0 a
Tongkol Merah (V2)	10.3 a	21.8 a	22.1a	20.9 a	22.3 a	20.2 a	20.7 a	20.7 a
Urea fertilizer (N)								
Urea 200 kg/ha (N1)	9.09 a	20.9 a	21.1a	20.3 a	21.7 ab	19.6 a	20.2 a	20.3 a
Urea 250 kg/ha (N2)	9.26 a	20.4 a	22.3a	21.6 a	19.7 b	24.0 a	20.3 a	20.4 a
Urea 300 kg/ha (N3)	8.98 a	21.1 a	22.0a	20.2 a	20.9 ab	19.5 a	20.1 a	20.5 a
Urea 350 kg/ha (N4)	10.1 a	21.5 a	22.9a	21.2 a	20.9 ab	19.9 a	20.3 a	20.3 a
Urea 400 kg/ha (N5)	10.7 a	21.6 a	22.3a	20.1 a	22.5 a	19.2 a	20.4 a	20.4 a

Note: Mean values followed by the same letter in the same column are not significantly different according to the LSD test at $\alpha = 0.05$.

23.14 mm, higher than a nitrogen dose of 225 kg/ha (equivalent to 489 kg/ha urea) at 26.52 mm. Different results were reported by Tobing *et al*. (2022), who stated that nitrogen significantly affected the stem diameter of hybrid corn at 7 WAS, with a nitrogen dose of 270 kg/ha (equivalent to 587 kg/ha urea) resulting in a stem diameter of 20.6 mm, larger than a nitrogen dose of 202.5 kg/ha (equivalent to 439 kg/ha urea) at 19.4 mm.

3.1.4. Corn Yield and Yield Components

The average values of yield and yield components in the harvested plots (Table 4) show significant differences due to urea on the weight of 100 seeds and cob diameter. The average values of yield and yield components in the harvested plots show significant differences due to the variety on yield components, including: wet cob weight, wet cob weight without husk, dry seed weight per plot, and conversion of dry seed weight (Table 4 and 5).

The average values of yield and yield components in the harvested plots are influenced by the variety (Table 4). The BISI-18 variety shows that the average yield and yield components are higher compared to the Tongkol Merah variety in the following variables:

1. The average conversion of dry seed weight per hectare shows that the BISI-18 variety (V1) produces an average dry seed weight per hectare of 11.7 tons, which is higher compared to the Tongkol Merah variety (V2) at 9.44 tons. Karasu (2012) found that when the nitrogen level increased to 300 kg/ha (equivalent to 652 kg/ha urea), it resulted in a dry seed weight of hybrid varieties at 13.3 tons/ha. Sharifi & Taghizadeh (2009) reported the highest hybrid corn yield of 10.5 tons/ha with a nitrogen application of 150 kg/ha (equivalent to 325.5 kg/ha urea).

Table 4. Effect of variety on the average values of yield and yield components in the harvested plots

Observation	BISI-18 Variety (V1)	Tongkol Merah Variety (V2)
Weight of 100 seeds (g)	28.2 a	28.8 a
Cob diameter (mm)	19.7 a	20.3 a
Conversion of dry grain weight (ton/ha)	11.7 a	9.44 b
Dry husk weight (g)	288 a	305 a
Dry seed weight per plot (kg/plot)	2.46 a	1.98 b
Dry cob weight (g)	300 a	315 a
Wet husk weight (g)	390 a	375 a
Wet cob weight (g)	547 a	530 a
Wet cob weight without husk (kg)	2.98 a	2.50 b
Wet cob weight (kg)	3.39 a	2.91 b
Cob length (cm)	15.8 a	14.9 a
Number of cobs	14.1 a	14.4 a
Number of plants	14.5 a	13.9 a

Note: Average values followed by the same letter in the same row are not significantly different according to the LSD test at $\alpha = 0.05$.

Table 5. Effect of nitrogen fertilizer dose on the average values of yield and yield components in the harvested plots

Observation	N1 (200 kg/ha)	N2 (250 kg/ha)	N3 (300 kg/ha)	N4 (350 kg/ha)	N5 (400 kg/ha)
Weight of 100 seeds (g)	28.4 b	28.1 b	28.1 b	28.3 ab	29.7 a
Cob diameter (mm)	20.4 ab	19.9 ab	18.8 b	20.9 a	19.8 ab
Conversion of dry seed weight (ton/ha)	10.3 a	10.1 a	10.1 a	11.1a	11.2 a
Dry husk weight (g)	289 a	283 a	274 a	324 a	316 a
Dry seed weight per plot (kg/plot)	2.16 a	2.12 a	2.12 a	2.34 a	2.35 a
Dry cob weight (g)	288 a	317 a	295 a	325 a	314 a
Wet husk weight (g)	373 a	366 a	351 a	424 a	398 a
Wet cob weight (g)	517 a	523 a	518 a	585 a	549 a
Wet cob weight without husk (kg)	2.65 a	2.58 a	2.64 a	2.93 a	2.91 a
Wet cob weight (kg)	3.07 a	2.94 a	3.02 a	3.38 a	3.33 a
Cob length (cm)	16.1 a	14.6 a	14.5 a	15.3 a	16.4 a
Number of cobs	14.1 a	13.7 a	14.3 a	14.8 a	14.2 a
Number of plants	14.0 a	13.8 a	14.0 a	14.8 a	14.3 a

Note: Average values followed by the same letter in the same row are not significantly different according to the LSD test at $\alpha = 0.05$.

2. The average dry seed weight per plot shows that the BISI-18 variety (V1) produces 2.46 kg of seeds per plot, higher than the Tongkol Merah variety (V2) at 1.98 kg. Tobing *et al*. (2022) found that hybrid varieties with a nitrogen dose of 270 kg/ha (equivalent to 586 kg/ha urea) had the highest yield potential with a seed weight of 5.4 kg per plot and a productivity of 11.1 tons/ha.
3. The average wet cob weight for the BISI-18 variety (V1) is 3.39 kg, higher than the Tongkol Merah variety (V2) at 2.91 kg. The average values of yield in the harvested plots show significant differences due to urea on the variables of weight of 100 seeds and cob diameter. Treatment with 400 kg/ha of urea (N5) results in a weight of 100 seeds at 29.7 g, higher compared to other urea treatments. The weight of 100 seeds is linear although there is no significant effect of nitrogen on the yield component of the conversion of dry seed weight, which is 16.0 tons/ha. This is consistent with the findings of Sharifi & Taghizadeh (2009) that a nitrogen dose of 240 kg/ha (equivalent to 521 kg/ha urea) significantly affects the weight of 100 seeds, resulting in a weight of 100 seeds at 31.7 g. According to Gheith *et al*. (2022), a nitrogen dose of 366 kg/ha (equivalent to 794.2 kg/ha urea) can produce a weight of 100 seeds at 45.8 and 42.2 g.

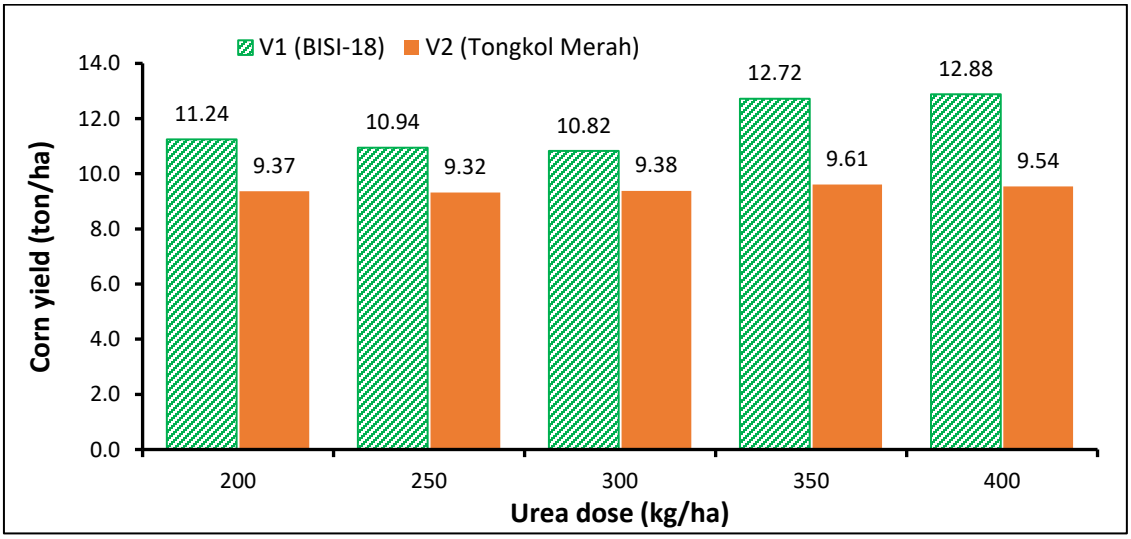

Figure 5. Graph of the conversion of dry seed weight

Treatment with 350 kg/ha of urea (N4) results in an average cob diameter of 20.9 mm, higher compared to other urea treatments (Table 4). Adhikari *et al*. (2021) reported that the differences in variety and nitrogen levels significantly affect the yield and yield components of corn. In this study, the V1N5 treatment produced a corn yield of 12.86 tons/ha of dry harvested corn, while the V2N4 treatment resulted in a corn yield of 9.57 tons/ha of dry harvested corn. Tobing *et al*. (2022) found that a nitrogen dose of 202 kg/ha (equivalent to 439 kg/ha urea) is the optimal dose to achieve high productivity in hybrid varieties. The graph of the conversion of dry seed weight is presented in Figure 5.

3.1.5. Nitrogen Use Efficiency

Table 6 shows the results of the analysis of nitrogen content in corn leaves when the vegetative phase reaches its maximum (7 WAS) and at the end of the generative phase. The results of ANOVA showed no interaction between fertilizer doses and varieties because the increase in growth rate and yield of each variety was not affected by the provision of different nitrogen fertilization.

Table 6. Nitrogen content in the corn leaves at the maximum vegetative and last generative phases

Treatment	Maximum vegetative (7 WAS)	Last generative (17 WAS
V1NI	3.92	1.46
V1N2	4.28	1.88
V1N3	3.90	1.67
V1N4	4.06	1.95
V1N5	3.68	1.88
V2NI	4.31	1.90
V2N2	3.90	1.97
V2N3	4.28	1.23
V2N4	4.56	1.38
V2N5	4.66	1.40

Table 7. Nitrogen Use Efficiency (NUE) Data (units)

Treatment	NUE Dry Leaf		NUE Dry Stem		NUE Dry Husk		NUE Dry Seed	
	7 WAS	17 WAS	7 WAS	17 WAS	7 WAS	17 WAS	7 WAS	17 WAS
V1N1	17.2	33.1	20.8	46.0	2.58	15.7	1.03	109
V1N2	16.6	29.7	12.8	40.8	2.94	15.1	0.64	91.8
V1N3	16.1	31.3	16.5	40.3	4.07	15.3	0.83	107
V1N4	17.6	24.2	16.9	29.5	3.00	10.0	1.01	66.4
V1N5	19.5	22.2	16.0	45.4	3.77	12.1	0.92	79.5
V2N1	18.7	5.4	15.7	36.5	3.96	14.8	1.32	68.0
V2N2	17.6	6.2	21.2	28.5	2.73	13.7	1.08	66.7
V2N3	15.3	2.2	13.0	49.2	4.41	25.1	1.46	97.0
V2N4	16.2	11.2	14.0	53.1	4.13	14.9	1.61	77.2
V2N5	14.7	1.7	14.8	49.5	3.80	12.2	0.59	77.0

Note: 7 WAP = maximum vegetative phase; 17 WAP = late generative phase

Nitrogen use efficiency (NUE) was evaluated using the total N analysis variable on corn leaves (Table 7) against the dry weight of leaves, stems, husks, and seeds. Tobing *et al*. (2022) stated that the optimal nitrogen dose of 188 kg/ha (equivalent to 407 kg/ha urea) results in a total N content on corn leaves at 7 weeks after sowing (WAS) ranging from 3.03-3.16%. The results of nitrogen analysis on corn leaves (Table 6) were used to determine the nitrogen use efficiency (NUE) on the variables of dry weight of leaves, stems, husks, and seeds, as presented in Table 7.

The NUE values for dry leaf weight (Table 7) in the vegetative phase show that the V1N5 treatment results in an NUE of 19.5 units and V2N1 at 18.7 units, while in the generative phase, the V1N1 treatment results in an NUE of 33.1 units and V2N4 at 11.2 units. The NUE values for dry stem weight (Table 7) in the vegetative phase show that the V1N1

treatment results in an NUE of 20.8 units and V2N2 at 21.2 units, while in the generative phase, the V1N1 treatment results in an NUE of 46.0 units and V2N4 at 53.1 units. Similar results were found by Gheith *et al*. (2022), where NUE increased by 22.9 units with a reduction in nitrogen dose to 192 kg/ha (equivalent to 416 kg/ha urea) during the vegetative phase from 2019 to 2020.

The NUE values for dry husk weight (Table 7) in the vegetative phase show that the V1N3 treatment results in an NUE of 4.07 units and V2N3 at 4.41 units, while in the generative phase, the V1N1 treatment results in an NUE of 15.7 units and V2N4 at 14.9 units. The NUE values for dry seed weight (Table 7) in the vegetative phase show that the V1N1 treatment results in an NUE of 1.03 units and V2N4 at 1.61 units, while in the generative phase, the V1N1 treatment results in an NUE of 109 units and V2N3 at 97.0 units.

3.2. Discussion

Urea treatment only affects the amount or magnitude of observed data on the growth rate variable. At a 95% significance level, the increase in leaf number, plant height, and stem diameter for both BISI-18 and Tongkol Merah varieties is greatly influenced by urea treatment in the early growth stages up to 5-7 WAP. Urea dosage up to 300 kg/ha can increase the number of leaves, plant height, and stem diameter. Urea dosage treatment shows significant differences at each observation age and growth variables, including leaf number, plant height, stem diameter, wet weight (stem and leaves), dry weight (stem and leaves), tassel length, cob number, wet weight (tassels, ears, husks, cobs, stalks, and seeds), stalk length, dry weight (leaves, husks, cobs, stalks, tassels, ears, and seeds), stalk diameter, number of rows per cob.

The growth rate of seed number per cob and dry seed weight increases with the increase in urea dosage up to 300 kg/ha. The V1N3 treatment results in 195 seeds/week and the V2N3 treatment in 79.4 seeds/week at 9-11 WAP, while the V1N3 treatment results in a dry seed weight of 35.8 g/week and the V2N3 treatment in 35.4 g/week. Nitrogen use efficiency (NUE) (Table 7) shows that NUE is not supported by the increase in corn production. The V1N1 treatment results in higher NUE compared to the Tongkol Merah variety on the variables of dry stem weight, dry leaf weight, dry husk weight, and dry seed weight in the late generative phase (17 WAP). Meanwhile, nitrogen analysis on corn leaves (Table 6) shows that the V1N1 treatment has a leaf nitrogen content of 1.46% at 17 WAP, lower compared to other treatments. Figure 5 shows that the V1N1 treatment results in a seed weight per hectare of 11.2 tons/ha, higher than the V1N2 and V1N3 treatments, but higher than the V1N4 treatment at 12.7 tons/ha. Thus, from this study, it can be concluded that using the BISI-18 variety with 200 kg urea dosage is more efficient compared to other treatments.

4. CONCLUSION

1. Increasing the urea fertilizer dosage from 200 kg/ha to 400 kg/ha does not increase the growth rate of BISI-18 and Tongkol Merah corn varieties.
2. The productivity of the BISI-18 corn variety is higher compared to the Tongkol Merah variety, as shown by the weight of husked wet cobs (g), weight of wet cobs (g), dry seed weight per plot (g), and yield of dry seed (tons/ha).
3. The yield of dry grain is 11.7 ton/ha for the BISI-18 variety, and 9.44 ton/ha for the Tongkol Merah variety.
4. Based on nitrogen use efficiency, a urea fertilizer dosage of 200 kg/ha with a corn yield of 11.2 ton/ha is more efficient in increasing the production of the BISI-18 variety compared to a urea dosage of 400 kg/ha with a corn yield of 12.8 ton/ha.

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