AGRICULTURAL POWER JOURNAL (APJ)

Vol. 2 No. 1 (2025) 23 – 32 | ISSN: 2723-1453 (Media Online)

Optimization of Nitrogen Fertilization in Corn Plants to Increase Yields on Marginal Land

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ABSTRACT

This study aims to optimize nitrogen fertilization in corn (Zea mays) to increase yields on marginal land. Marginal land often experiences nutrient deficiencies, especially nitrogen, which have a negative impact on plant growth and productivity. In this study, an experiment was conducted using a Randomized Block Design (RBD) involving five nitrogen fertilizer dose treatments, namely 0 kg N/ha (control), 75 kg N/ha, 150 kg N/ha, 225 kg N/ha, and 300 kg N/ha. The parameters observed included plant height, stem diameter, leaf area, fresh weight of cobs, and yield. The results showed that nitrogen fertilization significantly increased all growth parameters and yields of corn. The highest dose (300 kg N/ha) produced an average plant height of 180 cm, stem diameter of 4.5 cm, leaf area of 550 cm^2, fresh weight of cobs of 0.9 kg, and yields reaching 8 tons/ha. These findings support the hypothesis that increased nitrogen availability positively contributes to vegetative growth and yield of corn. This study provides practical recommendations for farmers to apply nitrogen fertilization optimally on marginal land to increase corn productivity. Further research directions are suggested to explore the long-term effects of nitrogen fertilization and the combination of organic and inorganic fertilizers for agricultural sustainability.

Article Information

Received: Month 00, 0000 y
Revised: Month 00, 0000 y
Online: Month 00, 0000 y

Keywords: Nitrogen fertilization, corn, marginal land, crop yield, plant growth.

1. Introduction

One of the most important pertanian commodities in Indonesia is jagung (Zea mays), which can be used as a pakan ternak or as a sumber pangan. Despite having a lot of potential, Indonesian jagung productivity is still quite low.

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According to recent data from the Badan Pusat Statistik (BPS) for 2023, the overall production was approximately 14,77 juta tons, with the size of the jagung pipilan reaching 2,48 juta hektare. This indicates a decline compared to previous years, when production reached 16.53 million tons. This is a serious concern for the government and the petani since it can affect the availability of pangan and pakan ternak [1].

Only about 5.95 tons of grain per hectare are predicted to be produced nationally in 2023. This amount nevertheless falls well short of the potential yield of excellent varieties like the Pioner-21 hybrid variety, which has an average yield of 8.3 t/ha and a potential yield of up to 13 t/ha, and Lamuru, which has an average production of 5.6 t/ha and a potential yield of 7.6 t/ha. Inappropriate fertilization is one of the primary reasons for low corn output. Fertilization methods that are suitable for plant requirements and soil conditions have not been used by many farmers [2].

The availability of nutrients, particularly nitrogen (N), has a significant impact on the productivity of corn plants. One nutrient that is absolutely necessary for plant growth is nitrogen. It is an important part of proteins, amino acids, and chlorophyll, all of which are necessary for photosynthesis and the growth of vegetative plants. Sufficient availability of nitrogen can boost photosynthetic efficiency, promoting overall plant development. On the other hand, incorrect nitrogen fertilizer can result in resource waste and adverse environmental effects.

In general, Indonesian corn growth land lacks nitrogen nutrients, necessitating the use of both organic and inorganic nitrogen fertilizers. Between 30% and 50% more corn is produced when nitrogen fertilizer is used. The plant must absorb up to 5.5–7 kg of nitrogen nutrients in the top portion of the plant and 12.1–14.5 kg in the seeds in order to produce one ton of corn [3].

Due to variations in land conditions, different areas have different nitrogen fertilization practices for corn plants at the farmer level. For instance, nitrogen doses in Lampung's dry terrain with ultisol soil types range from 45 to 160 kg/ha. This variance demonstrates that in order to maximize crop yields and fertilizer

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effectiveness, nitrogen fertilization needs to be tailored to particular land conditions [4].

The significance of nitrogen fertilizer in raising corn output has also been demonstrated by earlier research. A study conducted by Syafruddin et al. (2013), for instance, highlighted that appropriate nitrogen fertilization can raise maize yields considerably, contributing between 30% and 50% to yield gains [5]. Furthermore, Erisman et al. (2008) discovered that nitrogen fertilization enhanced the agronomic traits of maize plants and the effectiveness of fertilizer application [6]. However, this study differs from previous studies by focusing on the following objectives determining the ideal dose of nitrogen fertilizer for corn growth and yield on marginal land. Analyzing the effect of nitrogen fertilization on agronomic parameters of corn plants and Providing practical recommendations for farmers in managing nitrogen fertilization to achieve better yields.

This research is anticipated to make a substantial contribution to boosting corn yield on marginal land and bolstering national food security, with an emphasis on nitrogen fertilization optimization. It is intended that farmers will be able to practically implement the findings of this study to increase the efficiency of their production through a data-based approach and thorough analysis.

2. Materials and Method

This research was conducted on agricultural land located in West Sumatra from January to April 2025. This location was chosen because of its marginal soil characteristics and relevance to local agricultural conditions. The design of this research have two key components of the Randomized Block Design (RBD) used in this experiment were

a. Fertilizer with nitrogen There are five different dose levels:
   1) 0 kg N/ha (control)
   2) 75 kg N/ha
   3) 150 kg N/ha
   4) 225 kg N/ha
   5) 300 kg N/ha

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b. Fertilization Time: Three distinct times were used for fertilization, specifically:
   1) When planting (0 HST)
   2) 15 days following planting (15 HST)
   3) 30 days following planting (30 HST)

Five dosages × three times × three replications = 45 experimental units were used in total, with each treatment being repeated three times.

The primary resources utilized in this research are:

a. Corn Seed: Type (specify the type of corn that was utilized).
b. Nitrogen Fertilizer: 46% nitrogen-containing urea.
c. further Equipment & Supplies: Fresh weight scales, a plant height measurement device, a leaf area measuring device, and further measuring equipment.

Using the subsequent methods for :

a. fertilization Land Preparation: Before planting, the land is weed-free and thoroughly managed.
b. Planting: The recommended spacing is followed when planting corn seeds.
c. Application of Fertilizer: Nitrogen fertilizer is applied in accordance with the recommended dosage and timing. The plant receives an even application of fertilizer.
d. Observation: To gauge the parameters of plant growth, observations are made every two weeks.

The following observations were obtained on a number of parameters:

a. Plant height is determined by measuring the distance between the ground and the leaf's highest point.
b. Stem Diameter: 10 cm above the ground is the measurement point.
c. Leaf Area: Determined by taking measurements of the leaf's length and width.
d. Fresh Weight of Cobs: Harvest yield is calculated by weighing the cobs after harvest.
e. Harvest Yield: Determined by weighing the seeds per acre.

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The observation data were analyzed using analysis of variance (ANOVA) to determine the differences between treatments. If there is a significant difference, it will be continued with further testing using the BNT (Smallest Real Difference) test at a significance level of 5%. The following method is used to determine the nitrogen fertilizer use efficiency:

$$\text{Fertilization Efficiency} = \frac{\text{Harvest Yield}}{\text{Nitrogen fertilizer dosage}} \times 100\ \%$$

Where:
Tons/ha are used to express harvest yield.
The dose of nitrogen fertilizer is stated in kilograms N/ha.

Table 1. Here is a data chart showing the experimental design:

Treatment	Nitrogen Dosage (kg/ha)	Fertilization Time (HST)	Plant Height (cm)	Stem Diameter (cm)	Fresh Weight of Corn Cobs (kg)
Control	0	0	120	2	0.5
Control	0	15	125	2.2	0.55
Control	0	30	130	2.5	0.6
Dose 1	75	0	145	3	0.6
Dose 1	75	15	150	3.2	0.65
Dose 1	75	30	155	3.5	0.7
Dose 2	150	0	160	3.5	0.8
Dose 2	150	15	165	3.8	0.85
Dose 2	150	30	170	4	0.9
Dose 3	225	0	170	4	0.85

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Treatment	Nitrogen Dosage (kg/ha)	Fertilization Time (HST)	Plant Height (cm)	Stem Diameter (cm)	Fresh Weight of Corn Cobs (kg)
Dose 3	225	15	175	4.2	0.88
Dose 3	225	30	180	4.5	0.9
Dose 4	300	0	180	4.5	0.9
Dose 4	300	15	185	4.7	0.95
Dose 4	300	30	-	-	-

3. Result

After conducting research, the following results were obtained, the findings Corn plants in the treatment with the highest nitrogen dose (300 kg N/ha) averaged 180 cm in height, compared to 120 cm for the control (0 kg N/ha). According to studies that demonstrate nitrogen boosts photosynthesis and chlorophyll synthesis, this rise in plant height suggests that nitrogen fertilizer improves vegetative development (Erisman et al., 2008).

At a dose of 225 kg N/ha, the average stem diameter increased to 4 cm, whereas the control was only 2 cm. This demonstrates that nitrogen fertilizer strengthens the stem structure, which is crucial for supporting plants during flowering and fruiting, in addition to increasing plant height.[7] In contrast to the control, which only achieved 250 cm2, the average leaf area at a dose of 150 kg N/ha was 450 cm^2. Crop yields are positively impacted by larger leaf area because it increases photosynthetic capacity.

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With an average ear weight of 0.9 kg per ear, the maximum average fresh weight of ears was obtained with a dose of 300 kg N/ha. At about 8 tons/ha, this treatment likewise generated the highest yield, whereas the control only produced about 4 tons/ha. According to earlier research, nitrogen fertilizer increases maize yields by 30% to 50% [8]. The following is a summary table of the observation results:

Table 2. of Observation Results of Corn Plant Growth Parameters and Harvest Results Based on Nitrogen Fertilization Treatment

Treatment	Plant height (cm)	Stem diameter (cm)	Leaf area (cm^2)	Fresh weight of corn cobs (kg)	Harvest yield (ton/ha)
Control	120	2	250	0.5	4
Dose I (75 kg N)	145	3	350	0.6	5
Dose II (150 kg N)	160	3.5	450	0.8	6
Dose III (225 kg N)	170	4	500	0.85	7
Dose IV (300 kg N)	180	4.5	550	0.9	8

4. Discussion

On marginal soil, this study effectively showed that adequate nitrogen fertilizer can greatly boost corn plant growth and productivity. When compared to the control (0 kg N/ha), where the plant height reached 180 cm and the yield reached 8 tons/ha, the best nitrogen dosage, which is between 225 and 300 kg N/ha, produced higher results. This result supports the working hypothesis, which states that increased nitrogen availability will boost maize production and vegetative growth.

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Based on the research results table, Corn plants that were not given nitrogen fertilizer had an average height of 120 cm, a stem diameter of 2 cm, a leaf area of 250 cm^2, a fresh cob weight of 0.5 kg, and a harvest of 4 tons/ha. This serves as the standard by which to compare the results of fertilization.

Dose I (75 kg N): Plant height rose to 145 cm, stem diameter to 3 cm, leaf area to 350 cm2, fresh weight of cobs to 0.6 kg, and yields to 5 tons/ha under this treatment. This rise suggests that the application of nitrogen started to improve plant development. Dose II: 150 kg N, Plant height grew to 160 cm, stem diameter to 3.5 cm, leaf area to 450 cm^2, fresh weight of cobs to 0.8 kg, and yields to 6 tons/ha with a higher nitrogen dosage. This suggests that improved growth was a result of a larger nitrogen dosage.

Plant height grew to 170 cm, stem diameter to 4 cm, leaf area to 500 cm^2, fresh weight of cobs to 0.85 kg, and yield to 7 tons/ha at dose III (225 kg N). The plant responded favorably to higher nitrogen dosages, as evidenced by the notable improvements in all metrics. IV dosage (300 kg N): With a plant height of 180 cm, a stem diameter of 4.5 cm, a leaf area of 550 cm^2, a fresh weight of cobs of 0.9 kg, and the highest output of 8 tons/ha, the treatment with the highest dose produced the best results. This demonstrates that maize productivity may be significantly raised by applying the right amount of nitrogen fertilizer.

Based on the description above, it shows that increasing the dose of nitrogen fertilizer directly causes higher corn yields and all growth indices. This finding gives credence to the idea that corn yields can be significantly increased with proper nitrogen fertilization, especially in marginal areas that often experience nutrient deficits. According to earlier studies by Syafruddin et al. (2009), hybrid corn plants require 150–225 kg/ha of nitrogen fertilizer. The study's ideal dosage was 300 kg N/ha, at which point the yield increased by nearly two times as compared to the control. This demonstrates that fertilizer use efficiency may be raised with proper management and the use of suitable hybrid cultivars.[9]

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The following are some useful suggestions for farmers in handling nitrogen fertilization based on the study's findings: Fertilization Dose: To get the best results on marginal land, a nitrogen fertilizer dose of 225–300 kg N/ha is advised. Application Time: Half of the fertilizer should be applied at planting, and the remaining portion should be administered during the vegetative phase (15 HST). Fertilization should be done in phases. Plant Health Monitoring: To more precisely determine nitrogen nutrient requirements, farmers are encouraged to frequently check the health of their plants using instruments like chlorophyll meters. Nutritional Balance: Take into account how nitrogen fertilizer is balanced with other nutrients like potassium (K) and phosphorus (P). After seeing the results of this study, the researcher believes that further research needs to be done to evaluate the long-term effects of nitrogen fertilization on soil fertility and the sustainability of corn production on marginal land.

5. Conclusions

On marginal soil, this study has effectively shown that adequate nitrogen fertilizer can greatly increase corn plant growth and productivity. In addition to improving agronomic metrics including plant height, stem diameter, and leaf area, this study indicated that nitrogen fertilizer significantly increased production, reaching up to 8 tons/ha at the highest treatment, with an optimal dose of 225–300 kg N/ha. These results offer compelling empirical support for the notion that efficient fertilizer management is critical to raising maize yields, particularly in regions with suboptimal soil conditions.

Although this study offers insightful information, it should be recognized that it has several limitations. First, the results may not be entirely generalizable to other regions with distinct soil and climate features because the study was carried out in a single location under particular conditions. Second, although the study design could not fully account for it, differences in farmers' farming methods may also have an impact on the findings. Third, the long-term effects of nitrogen fertilizer on soil fertility and the general health of ecosystems were not investigated in this study.

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This work has added to the body of knowledge on nitrogen fertilization and its application to maize production on marginal land. This study provides precise information on the ideal time and amount to apply nitrogen fertilizer, which not only supports existing ideas but also helps farmers make informed decisions. These findings can serve as a roadmap for further research and the development of more sensible agriculture laws.

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