JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 1 January 2025

DOI :https://doi.org/10.36378/juatika.v7i1.4231
eissn 2656-1727
pissn 2684-785X
pages : 331 – 334

RESEARCH ARTICLE Open Access

Growth Optimization of Gamma-Irradiated Local Corn (Zea mays L.) Varieties from North Sumatra Using KCl Fertilizer

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Abstract

The local variety of corn in North Sumatra (*Zea mays* L.) exhibits production weaknesses, particularly in the Labuhanbatu area, where yields remain low. This study aims to evaluate the growth of local corn plants in North Sumatra after applying various doses of potassium chloride (KCl) fertilizer. The research was conducted in an experimental field located in Perbaungan Village, Bilah Hulu District, Labuhanbatu Regency, North Sumatra, from December 2024 to February 2025. The study employed a Non-Factorial Complete Random Design (RAL) consisting of five treatment levels, each replicated four times: Control, 2 grams of KCl per polybag, 4 grams of KCl per polybag, 6 grams of KCl per polybag, and 8 grams of KCl per polybag. The results indicated that the most effective treatment was the P4 treatment (8 grams per polybag). Corn plants that received KCl fertilizer demonstrated superior growth to those that did not or were in the control group.

Keywords: North Sumatra Local Varieties of Corn, KCl Fertilizer, Drought Stress, Gamma-Ray Irradiation, Corn Plant Growth

1. Introduction

Corn is one of the most essential commodities in Indonesia, following rice. It plays a crucial role in meeting domestic food, feed, and industrial demands, which tend to rise annually in conjunction with population growth and the expansion of the food and feed industries. Corn is significant as a staple food and serves as a substitute for rice due to its high nutritional value and crude fiber content. In North Sumatra, corn farming ranks as the second largest agricultural commodity after rice (Asahan, 2014)

Efforts to increase the production of local corn plants in North Sumatra continue to be improved. One of the factors that inhibits the growth of corn plants is drought stress; therefore, it is necessary to develop local corn varieties in North Sumatra that are resistant to drought stress and pests and diseases. (Lestari et al ., 2020) .

Corn development is needed to increase the availability of quality seeds. One of the efforts made in developing local corn varieties in North Sumatra is to use one of the technologies, namely gamma-ray irradiation. Gamma rays are electromagnetic rays with high energy that have been proven to cause genetic changes in corn plants. In addition, mutation breeding is a technique used to obtain high-quality corn seeds. (Try Wulansyah et al., 2017) . In this process, mutations can be induced to change plants' genetic composition. Local corn varieties in North Sumatra were chosen because of their good adaptation to local environmental conditions, but they often experience limited potassium nutrients that affect their growth and production. Using KCl fertilizer is expected to overcome potassium deficiency in these local varieties, thereby increasing crop yields and resistance to environmental stress.

KCl fertilizer is one of the primary sources of potassium used in agriculture to support plant growth. Potassium plays an essential role in various physiological processes of plants, such as photosynthesis, regulation of osmotic pressure, and increasing resistance to environmental stress. In corn plants, providing KCl can help boost growth, accelerate cob formation, and increase yields by improving the efficiency of water and nutrient use. However, the use of KCl fertilizer also has several problems. The high chloride content in this fertilizer can be toxic to plants if given excessively, causing physiological disorders such as chlorosis and decreased productivity. In addition, dependence on inorganic fertilizers such as KCl

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can cause nutrient imbalances in the soil and increase the risk of land degradation if not accompanied by good fertilization management. Therefore, the administration of KCl to corn must be carried out in the right dose and combined with sustainable agricultural practices.

The gamma ray irradiation method is a technique that can increase genetic variation in the formation of plant varieties. In addition to gamma-ray irradiation technology, fertilization can influence plant growth. One of the widely used fertilizers is KCl fertilizer. KCl fertilizer is a chemical fertilizer that contains potassium (60%) and chloride (40%) nutrients, which can help increase plant growth optimally. In addition, potassium also plays an essential role in increasing plant resistance to environmental stress.

KCl fertilizer application can be made in the vegetative phase; however, farmers usually provide KCl fertilizer in the generative phase to increase the weight and quality of agricultural commodity production, including local corn plants. KCl fertilizer is a potassium source commonly used in corn cultivation. However, the optimal dose of KCl fertilizer for local corn varieties of North Sumatra has not been widely studied. This study aims to determine the effect of giving various doses of KCl fertilizer on the components of the growth results of local corn varieties of North Sumatra.

2. Material and Methods

2.1. Place and Time of Research

This research was conducted in an experimental field in Perbaungan Village, Bilah Hulu District, Labuhanbatu Regency, North Sumatra, at coordinates 2 ° 3'25.2 "N and 99 ° 58'15.6" E with an altitude of 45 MDPL. This research was conducted from December 2024 to February 2025.

2.2. Research Materials and Tools

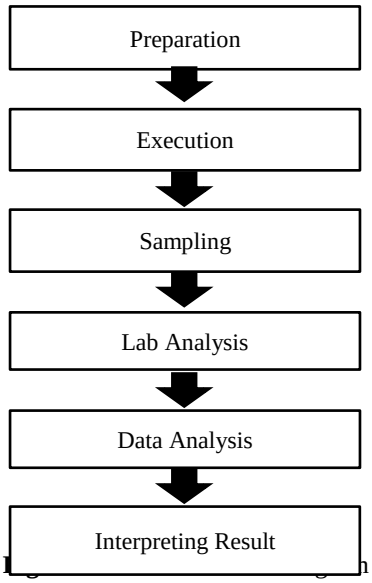
The research materials used include local North Sumatra corn seeds, KCl fertilizer, water, and topsoil. The research tools used are 35x35 cm polybags, stationery, meters, labels, calipers, watering cans or buckets, cameras, and other tools supporting this research's implementation.

2.3. Research methods

This study used a Non-Factorial Completely Randomized Design (CRD) of 5 treatment levels. Each was repeated 4 times so that the total experiment was 20 plants. The treatments in this study included four levels of KCl fertilizer doses, namely no treatment, 2 grams of KCl/polybag, 4 grams of KCl/polybag, and 6 grams of KCl/polybag, 8 grams of KCl/polybag, with:

Number of repetitions	: 4 repetitions
Distance between polybags	: 50 cm
Number of plants	: 20
Polybag soil weight	: 15 kg

2.4. Research Implementation



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2.5. Data analysis

The research data were analyzed using Analysis Of Variance (ANOVA). Data analysis was carried out using a non-factorial completely randomized design (CRD) method, and if there was a significant difference, it was further tested with a mean difference test based on the Tukey test (HSD) at a level of 5%. The variance analysis equation model is as follows:

$$\mathbf{Yij = \mu i + \tau i + \varepsilon ij \text{ or } Yij = \mu i + \varepsilon ij}$$

Information:

Yij = Observations in the ith treatment and jth replication
μ = General mean
τi = Effect of treatment i
εij = Random effect on the ith treatment and jth replication

The parameters observed were plant height (cm), number of leaves (strands), and stem diameter. These data were analyzed using Microsoft Excel.

3. Results and Discussion

3.1. Corn Plant Height (cm)

The analysis of the height of local corn plants in North Sumatra shows that the treatment of KCl fertilizer on the growth of local corn plants gives different results.

The results of the analysis of variance showed that the KCl Fertilizer treatment had a significant effect at the ages of 2, 6, and 8 Weeks After Planting (MST) but had no significant impact at the age of 4 Weeks After Planting (MST) on plant height. Table 1 explains that there was an increase in the growth of corn plant height due to the KCL Fertilizer treatment at the ages of 2, 4, 6, and 8 Weeks After Planting (MST), where each age of plant height that had a significant effect at the ages of 2 MST, 6 MST, and 8 MST showed the highest data, namely at the age of 8 MST

in the P4 treatment with a dose of 8 grams/polybag, which was 153.275.

Table 1. Comparison of the height of local corn plants in North Sumatra

Treatment	Plant height			
	2 MST	4 MST	6 MST	8 MST
Control	38.7 ± 2.63a	65.22 ± 4.07a	84.9 ± 3.56a	108.15 ± 3.18a
2 grams KCl	45.47 ± 2.63 b	70.82 ± 4.07a	95.5 ± 3.56b	115.3 ± 3.18b
4 grams KCl	52.7 ± 2.63b	73.97 ± 4.07a	96.6 ± 3.56b	125.57 ± 3.18b
6 grams KCl	54.02 ± 2.63b	77.65 ± 4.07a	99.6 ± 3.56b	127.12 ± 3.18b
8 grams KCl	54.02 ± 2.63b	77.92 ± 4.07a	101.17 ± 3.56b	153.27 ± 3.18c

Description: Numbers followed by the same letter in the same column are not significantly different in the Tukey test (HSD) at 5% level.

This result is because KCl fertilizer increases the soil KTK of nutrients plants absorb, affecting corn plant height growth. (Selatan et al ., 2020) KCL fertilizer treatment has a significant effect because KCL fertilizer contains potassium, which is one of the three primary macronutrients needed for plant growth, especially for plant height. (Arif et et al ., 2022) .

3.2. Number of Corn Leaves

The results of the analysis of variance showed that the KCl Fertilizer treatment had a significant effect at the age of 6 and 8 Weeks After Planting (MST) but had no significant impact at the age of 2 and 4 Weeks After Planting (MST) on the number of leaves. Table 2. Explains that there was an increase in growth in the number of corn plant leaves due to the KCl Fertilizer treatment at the age of 6 and 8 Weeks After Planting (MST), where the P4 treatment at each age had a significant effect on the number of leaves being the highest, namely at the age of 6 MST with an average of 7.75 and 8 MST with an average of 11.25.

Table 2. Comparison of the number of leaves of local corn plants in North Sumatra

Treatment	Number of Leaves			
	2 MST	4 MST	6 MST	8 MST
Control	4.75 ± 0.13 a	5.75 ± 0.69 a	6 ± 0.32 a	8.5 ± 0.37 a
2 grams KCl	4.5 ± 0.13 a	6.5 ± 0.69 a	7.25 ± 0.32 b	8.5 ± 0.37 a
4 grams KCl	4.75 ± 0.13 a	7 ± 0.69 a	7 ± 0.32 b	8.75 ± 0.37 b
6 grams KCl	4.5 ± 0.13 a	7.25 ± 0.69 a	7.5 ± 0.32 b	9.5 ± 0.37 c
8 grams KCl	4.75 ± 0.13 a	7.5 ± 0.69 a	7.75 ± 0.32 b	11.25 ± 0.37 c

Description: Numbers followed by the same letter in the same column are not significantly different in the Tukey test (HSD) at the 5% level.

According to Rehm et al . (2002) and Lakudzala (2002), Potassium (K) plays an essential role in the physiological process of protein formation, water, nutrient and carbohydrate transport, photosynthesis, N utilization, early growth stimulation, and in insects and disease resistance. In addition, it promotes assimilate transport, control of stomata opening, enzyme activation in plants, especially those responsible for energy transfer and the formation of sugar, starch, and protein, as well as the promotion of microbial activity and nutrition and human and livestock health. Potassium deficiency causes stunted growth, leaves appear dry and burnt on the sides, inhibits the formation of carbohydrates in seeds, the leaf surface shows uneven chlorotic symptoms, and the appearance of brown spots similar to disease symptoms on the dark green parts. (Ariawan et al ., 2016) .

3.3. Stem Diameter

The results of the analysis of variance showed that the KCl Fertilizer treatment had a significant effect at the ages of 4, 6, and 8 Weeks After Planting (MST) but had no significant impact at the age of 2 Weeks After Planting (MST) on stem diameter. Table 3. Explains an increase in growth in the diameter of corn plant stems due to the KCl Fertilizer treatment at the ages of 4, 6, and 8 Weeks After Planting (MST). In contrast, the P3 treatment at 8 MST had the highest significant stem diameter with an average of 2.3125.

Table 3 shows an increase in the diameter of the corn plant stem that was applied with KCl fertilizer at each application dose compared to the control or without treatment (P0). With increasing doses, the diameter of the corn plant stem also increases. Plants absorb potassium elements in large quantities, so if potassium in the soil is insufficient, it will affect the condition of the plant. The difference in stem diameter is increasingly significant with the increasing age of the corn plant, namely at the observation age of 8 MST. An adequate potassium supply will help corn plants form strong and large stems. According to Utomo (2015), potassium elements can increase carbohydrate synthesis and translocation, increasing cell wall thickness and stem strength. In addition, potassium is also found in plants in the K + cation which plays a vital role in respiration and photosynthesis.

Table 3. Comparison of stem diameters of local corn plants in North Sumatra

Treatment	Stem Diameter			
	2 MST	4 MST	6 MST	8 MST
Control	0.35 ± 0.06 a	1.17 ± 0.36 a	1.25 ± 0.08 a	1.37 ± 0.07 a
2 grams KCl	0.47 ± 0.06 a	1.47 ± 0.36 b	1.59 ± 0.08 a	1.71 ± 0.07 b
4 grams KCl	0.47 ± 0.06 a	1.84 ± 0.36 c	2.03 ± 0.08 b	2.15 ± 0.07 c
6 grams KCl	0.5 ± 0.06 a	1.98 ± 0.36 c	2.17 ± 0.08 b	2.31 ± 0.07 c
8 grams KCl	0.5 ± 0.06 a	2.03 ± 0.36 c	2.18 ± 0.08 b	2.27 ± 0.07 c

Description: Numbers followed by the same letter in the same column are not significantly different in the Tukey test (HSD) at 5% level.

Figure 2. Research Documentation

4. Conclusion

Based on the research results, this study demonstrates that applying KCl fertilizer significantly enhances plant height, leaf count, and stem diameter in corn plants. KCl fertilizer is a vital source of potassium, essential for photosynthesis, water regulation, and improving plant resistance to diseases. The findings indicate that the most effective treatment was the P4 treatment (8 g per polybag). Corn plants that received KCl fertilizer exhibited superior growth compared to those that did not receive any fertilizer (P0 or no treatment).

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