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Optimizing Nasa Liquid Organic Fertilizer Concentration and NPK Fertilizer Dosage 16-16-16 on the Growth and Yield of Glutinous Corn (*Zea mays* ceratina L.)

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Abstract

Glutinous corn (*Zea mays* ceratina L.) is a distinctive variety known for its unique starch characteristics and high economic value. One of the challenges affecting glutinous corn plants' productivity is the soil's low nutrient content. To address this issue, improving the fertilization system is essential, which can be achieved by balancing the application of chemical fertilizers and organic fertilizers within the cultivation system. This study aims to identify the optimal doses of liquid organic fertilizer and NPK 16-16-16 fertilizer to enhance crop yields and improve fertilization efficiency. The research employed a factorial randomized block design (RAK) with two factors. The first factor is the dose of liquid organic fertilizer (C), which includes the following levels: control (without POC), 2 ml/l, 4 ml/l, and 6 ml/l. The second factor consists of the control (recommended dose of 4.5 g/plant) and doses of 2.25 g/plant, 3 g/plant, and 3.75 g/plant. Reason: Improved clarity, readability, and technical accuracy while maintaining the original meaning. The results indicated an interaction between the combination of liquid organic fertilizer and NPK 16-16-16 fertilizer treatments concerning the sugar content of glutinous corn. The treatment without applying liquid organic fertilizer (0 ml/l) yielded the highest cob weight without husks, measuring 211.22 g. Additionally, the application of NPK 16-16-16 fertilizer resulted in glutinous corn's most significant plant height at both 14 and 42 days after planting (DAP). It contributed positively to the sugar content of the corn.

Keywords: Corn, NPK, Organic, Soil, *Zea mays*

1. Introduction

Glutinous corn (*Zea mays* ceratina L.), also known as waxy corn, is a food crop characterized by a unique variety with high economic value and gaining popularity among consumers. The distinctive feature of this corn is its exceptionally high amylopectin content, which ranges from 90% to 99%. This elevated amylopectin level contributes to glutinous corn's stickier and softer texture when cooked (Suarni et al., 2019). Despite its promising market potential and health benefits, such as aiding in regulating glucose absorption for people with diabetes, glutinous corn cultivation in Indonesia remains limited, and its productivity is relatively low. Several factors contribute to this low productivity, including climate change, pest infestations, declining seed quality, and insufficient nutrient content in the soil due to suboptimal fertilization practices.

One of the strategic measures to enhance the productivity of glutinous corn is to optimize the fertilization system by applying a combination of liquid organic fertilizer and inorganic fertilizer, such as NPK 16-16-16. Liquid organic fertilizer contains essential compounds, including amino acids, plant hormones, and vitamins, which can improve the biological quality of the soil and support plant growth. Previous research conducted by Edy et al. (2023) demonstrated that applying liquid organic fertilizer at a dosage of 4 ml/l can significantly increase the growth and yield of corn plants, particularly in plant height, cob length, and cob diameter. However, this study did not specifically investigate the effects of combining liquid organic fertilizer with NPK 16-16-16 inorganic fertilizer. This study presents a novel approach

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by directly examining the impact of combining liquid organic fertilizer with NPK 16-16-16 fertilizer on the yields of glutinous corn plants. The findings are expected to provide valuable information for enhancing corn production. Liquid organic fertilizers contain macro and microelements that facilitate the dissolution of chemical fertilizer residues and regulate nutrient distribution in the soil (Oesman & Rahmaniah, 2022). In contrast, NPK 16-16-16 fertilizer supplies three essential macronutrients in a single application, making it both efficient and effective in promoting plant growth and fruit development. NPK fertilizers are particularly beneficial for stimulating plant height and stem diameter (Puspadewi et al., 2016).

The high level of inorganic fertilizer use by farmers, coupled with significant price increases, is one of the main factors causing fertilizer shortages in the field. This condition requires an alternative solution: implementing an integrated fertilization system that combines inorganic fertilizers with organic fertilizers without reducing crop production. The availability of macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as the content of amino acids, vitamins, and phytohormones, can stimulate plant physiological processes naturally. Applying a combination of organic and inorganic fertilizers not only increases efficiency in fertilization but also maintains the continuity of nutrients in the soil. It is an effective strategy in overcoming the crisis of inorganic fertilizer availability without reducing the productivity of glutinous corn. This study aims to determine the best dosage of liquid organic fertilizer and NPK 16-16-16 fertilizer for the growth and yield of glutinous corn plants.

2. Material and Methods

This research was conducted in Berbek Village, Sidoarjo Regency, East Java, at coordinates 7°20'33.3"S and 112°45'48.1"E with an altitude of 5 meters above sea level. The materials used were glutinous corn seeds of the Kumala F1 variety, POC Nasa, and NPK Mutiara 16-16-16 fertilizer. The tools used were plant markers, calipers, rulers, refractometers, digital scales, and meters.

Figure 1. Research Flow Diagram

The study used a factorial Randomized Block Design (RAK) with two factors and 3 repetitions. The first factor is the Liquid Organic Fertilizer (C) dose, consisting of 4 treatment levels: control (Without POC), 2 ml/l, 4 ml/l, and

6 ml/l. The second factor is NPK Fertilizer 16-16-16 (N) with 4 treatment levels: control (Recommended dose of NPK 16-16-16 4.5 g/plant), 2.25 g/plant, 3 g/plant, and 3.75 g/plant.

Plant length (cm) was measured every 7 days starting from 14-49 DAP or until the vegetative period. Plant length was calculated from the surface of the plant to the longest part of the plant, measured with a ruler or meter. The number of leaves (strands) was calculated every 7 days starting from 14-49 DAP or until the vegetative period. The number of leaves was calculated manually by counting the leaves that had opened completely and were green. The weight of the corn cobs with and without husks was calculated by weighing the glutinous corn cobs using a digital scale. Each sample of glutinous corn that had been harvested was measured for diameter using a vernier caliper. The sugar content of glutinous corn was measured using a refractometer and was carried out after harvest. The first stage began by taking several corn kernels from the middle of the cob and mashing them. The mashed corn was placed on the surface of the prism, and the sugar content results could be seen on the lens with the appearance of the brix value on the scale.

The observation data were analyzed statistically using Analysis of Variance (ANOVA). Data analysis was carried out using a Randomized Block Design (RAK). If there was a real or very real effect on the treatment, the BNJ (Honestly Significant Difference 5%) test was carried out using the Microsoft Excel 2013 application.

3. Results and Discussion

The results of the data analysis indicated that the application of NPK 16-16-16 fertilizer significantly affected plant height at 14 and 42 days after planting (DAP) (Table 1). Additionally, the application of liquid organic fertilizer had a notable impact on cob weight with husk, while the NPK 16-16-16 fertilizer treatment also influenced the sugar content of glutinous corn plants (Tables 3 and 4). Furthermore, liquid organic fertilizer and NPK 16-16-16 treatments affected the sugar content parameters (Table 5).

Table 1. Average Plant Length and Number of Leaves at Age 14-42 DAP on Liquid Organic Fertilizer and NPK Fertilizer 16-16-16 Treatment

Treatment	Average Length of Corn Plant (cm)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Liquid Organic Fertilizer Dosage					
C0 (0 ml/l)	30.32 ± 0.64	51.50 ± 1.57	95.42 ± 2.40	146.75 ± 1.70	181.67 ± 1.70
C1 (2 ml/l)	30.58 ± 0.75	51.42 ± 1.37	93.26 ± 1.69	148.25 ± 1.87	181.71 ± 1.61
C2 (4 ml/l)	30.22 ± 0.51	50.38 ± 1.04	94.43 ± 2.16	149.44 ± 1.40	181.56 ± 1.54
C3 (6 ml/l)	29.46 ± 0.68	51.43 ± 0.66	98.58 ± 2.29	150.86 ± 1.56	183.61 ± 1.63
BNJ 5%	tn	tn	tn	tn	tn
NPK Fertilizer Dosage 16-16-16					
N1 (4.5 g)	30.76 ± 0.84 ab	51.10 ± 1.45	92.68 ± 2.12	148.28 ± 2.70	183.01 ± 1.94 ab
N2 (2.25 g)	31.69 ± 0.34 b	53.22 ± 1.19	100.24 ± 2.52	149.42 ± 1.21	180.85 ± 0.83 ab
N3 (3 g)	29.03 ± 0.49 a	49.49 ± 0.99	94.19 ± 1.73	147.31 ± 1.22	178.97 ± 0.81 a
N4 (3.75 g)	29.10 ± 0.48 a	50.92 ± 0.90	94.58 ± 1.76	150.31 ± 0.94	185.71 ± 1.84 b
BNJ 5%	2.26	tn	tn	tn	6.41

Description: Numbers followed by the same letter indicate not significantly different in the 5% BNJ test

The application of a single factor of NPK 16-16-16 fertilizer dose on glutinous corn has been proven to significantly affect the length of glutinous corn plants at 14 DAP and 42 DAP. Application of NPK 16-16-16 fertilizer (2.25 g) gave the highest length of 31.69 cm and was significantly different from the dose (3 g) of 29.03 cm and the dose (3.75 g) of 29.10 cm (Table 1). This shows that in the early growth phase, NPK fertilizer with a moderate dose tends to be more optimal in stimulating the early vegetative growth of corn plants. Too high a dose of NPK at the beginning of the vegetative phase can reduce plant length because excess nutrients can disrupt the physiological balance of the plant. Excess nitrogen can inhibit the absorption of other nutrients, such as potassium, which is essential for metabolism and the formation of plant tissue. This disrupts the synthesis of essential proteins and enzymes for cell growth, ultimately inhibiting plant elongation. Application of N fertilizer after planting must still pay attention to plant needs, otherwise it will have a detrimental effect on the early development of the plant (Palupi et al., 2017).

The administration of a dose of 3.75 g/plant at 42 DAP with NPK 16-16-16 fertilizer resulted in the highest plant length of 185.71 cm, significantly different from the dose (3 g) with a height of 178.97 cm. This indicates that glutinous corn plants respond better to higher doses of NPK fertilizer in the generative phase, primarily to support maximum stem and leaf growth before cob formation. The nutrients contained in NPK 16-16-16 fertilizer help meet plant needs so that they can stimulate plant height, stem diameter growth, and increase the number of leaves. Application of NPK 16-16-16 fertilizer in high doses before the plant's generative phase can positively impact plant height and overall growth vigor. As the age of the plant increases, the root system will develop and spread widely into the soil, so that the plant can absorb nutrients from NPK 16-16-16 fertilizer more efficiently (Hamid, 2019).

Table 2. Average Number of Leaves in Corn Plants Aged 14-42 DAP on Liquid Organic Fertilizer and NPK Fertilizer 16-16-16 Treatment

Treatment	Average Number of Corn Plant Leaves (strands)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Liquid Organic Fertilizer Dosage					
C0 (0 ml/l)	4.58 ± 0.07	6.14 ± 0.08	9.83 ± 0.06	11.78 ± 0.13	12.00 ± 0.00
C1 (2 ml/l)	4.67 ± 0.09	6.08 ± 0.06	9.83 ± 0.06	11.83 ± 0.12	12.00 ± 0.00
C2 (4 ml/l)	4.61 ± 0.07	6.03 ± 0.03	9.83 ± 0.08	12.00 ± 0.00	12.00 ± 0.00
C3 (6 ml/l)	4.53 ± 0.10	6.00 ± 0.00	9.92 ± 0.04	12.00 ± 0.00	12.00 ± 0.00
BNJ 5%	tn	tn	tn	tn	tn
NPK Fertilizer Dosage 16-16-16					
N1 (4.5 g)	4.67 ± 0.09	6.11 ± 0.06	9.78 ± 0.07	11.83 ± 0.12	12.00 ± 0.00
N2 (2.25 g)	4.75 ± 0.06	6.08 ± 0.06	9.92 ± 0.06	11.89 ± 0.11	12.00 ± 0.00
N3 (3 g)	4.53 ± 0.09	6.00 ± 0.00	9.92 ± 0.04	11.89 ± 0.07	12.00 ± 0.00
N4 (3.75 g)	4.44 ± 0.06	6.06 ± 0.06	9.81 ± 0.06	12.00 ± 0.00	12.00 ± 0.00
BNJ 5%	tn	tn	tn	tn	tn

The provision of liquid organic fertilizer has been proven to affect the weight parameters of corn cobs without husks significantly. The study's results showed that without liquid organic fertilizer (0 ml/l), the highest weight of corn cobs without husks was 211.22 g (Table 3). Treatment without liquid organic fertilizer (0 ml/l) produced the highest average weight of corn cobs without husks of 211.22 g, which was significantly different from other treatments. Meanwhile, treatment with liquid organic fertilizer, especially at a high dose (6 ml/l), produced a lower weight of 186.58 g. This shows that adding liquid organic fertilizer in a specific dose does not necessarily increase the production of corn cobs.

Table 3. Average Length of Corn Cob Without Husk, Weight of Corn Cob with Husk Weight of Cobs Without Husks, and Weight of Cobs with Husks per Plot Glutinous Corn Plants in Liquid Organic Fertilizer and Organic Fertilizer Treatment NPK 16-16-16

Liquid Organic Fertilizer Dosage	Length of Corn Cob Without Husk	Weight of Cob with Cob	Weight of Corncob Without Husk	Weight of Cob with Cob Per Plot
C0 (0 ml/l)	19.79 ± 0.35	300.72 ± 11.75	211.22 ± 8.80 b	2.86 ± 0.09
C1 (2 ml/l)	18.88 ± 0.47	269.42 ± 15.36	193.06 ± 10.83 ab	2.64 ± 0.10
C2 (4 ml/l)	19.07 ± 0.50	271.31 ± 16.06	197.69 ± 9.83 ab	2.67 ± 0.12
C3 (6 ml/l)	18.70 ± 0.33	257.97 ± 14.59	186.58 ± 7.24 a	2.61 ± 0.12
BNJ 5%	tn	tn	22.79	tn
NPK Fertilizer Dosage 16-16-16	**Length of Corn Cob Without Husk**	**Weight of Cob with Cob**	**Weight of Corncob Without Husk**	**Weight of Cob with Cob Per Plot**
N1 (4.5 g)	19.13 ± 0.34	266.36 ± 14.38	194.44 ± 8.61	2.51 ± 0.12
N2 (2.25 g)	19.19 ± 0.46	284.83 ± 15.65	201.28 ± 8.97	2.73 ± 0.11
N3 (3 g)	18.80 ± 0.46	268.89 ± 14.31	189.47 ± 9.78	2.73 ± 0.10
N4 (3.75 g)	19.32 ± 0.47	279.33 ± 16.07	203.36 ± 10.59	2.81 ± 0.09
BNJ 5%	tn	tn	tn	tn

Note: Numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

Liquid organic fertilizer contains various sources of micronutrients and natural growth hormones. If the dosage is incorrect, especially at high concentrations, it can cause nutrient imbalance or phytotoxicity in plants. Excessive use of liquid organic fertilizers can interfere with the absorption of macronutrients by plants due to competition between ions, so the growth and yield of corn plants decrease. High concentrations of liquid organic fertilizer solutions can create high osmotic pressure in the root zone, inhibiting plant water absorption. The supply of nutrients, one of which is nitrogen, cannot meet plant needs, resulting in disrupted reproductive growth of corn plants. This causes physiological stress reflected in low yield production, including cob weight (Purba et al., 2019).

Application of liquid organic fertilizer to plants does not always increase yields if the soil conditions are sufficiently fertile. The high weight of the cob without husk of 211.22 g in the liquid organic fertilizer treatment (0 ml/l) is thought to be because the soil in the research area already has sufficient nutrient content to support the physiological processes of corn plants without the need for additional liquid organic fertilizer. This finding differs from the research conducted by Edy et al. (2023), which states that the provision of liquid organic fertilizer can increase the weight of corn cobs without husks. This difference is likely caused by differences in soil characteristics at the research location. In Edy's research, the yield increase occurred in soil with a relatively low nutrient content, so the plants responded positively to the addition of nutrients from liquid organic fertilizer. This can be seen in the treatment of high-

dose liquid organic fertilizer (6 ml/l), which produced the lowest weight of corn cobs without husks, 186.58 g. This indicates the possibility of an imbalance of nutrients or phytotoxic effects due to the accumulation of certain organic compounds that inhibit the absorption of the primary nutrients, such as nitrogen and potassium. In fertile soil conditions and sufficient nutrient content, adding fertilizer cannot provide a significant positive effect and may even cause negative impacts if excessive.

Table 4. Average Diameter of Cobs with Husks, Diameter of Cobs without Husks, and Sugar Content of Glutinous Corn Plants in Liquid Organic Fertilizer and NPK 16-16-16 Fertilizer Treatments

Liquid Organic Fertilizer Dosage	Diameter of Cob with Cob	Diameter of Corn Cob Without Husk	Sugar Content
C0 (0 ml/l)	5.23 ± 0.07	4.39 ± 0.07	11.33 ± 0.18
C1 (2 ml/l)	5.05 ± 0.11	4.32 ± 0.07	11.41 ± 0.18
C2 (4 ml/l)	5.08 ± 0.10	4.32 ± 0.06	11.43 ± 0.15
C3 (6 ml/l)	4.96 ± 0.08	4.31 ± 0.05	11.51 ± 0.20
BNJ 5%	tn	tn	tn
NPK Fertilizer Dosage 16-16-16	**Diameter of Cob with Cob**	**Diameter of Corn Cob Without Husk**	**Sugar Content**
N1 (4.5 g)	5.02 ± 0.09	4.29 ± 0.07	11.41 ± 0.13 ab
N2 (2.25 g)	5.15 ± 0.09	4.37 ± 0.05	11.71 ± 0.17 b
N3 (3 g)	5.08 ± 0.09	4.33 ± 0.06	11.16 ± 0.16 a
N4 (3.75 g)	5.07 ± 0.11	4.35 ± 0.07	11.38 ± 0.22 ab
BNJ 5%	tn	tn	0.50

Note: Numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

Balanced fertilization with a dose of NPK 16-16-16 also significantly affected the sugar content. The highest sugar content of glutinous corn was obtained with a dose of NPK 16-16-16 fertilizer (2.25 g) of 11.71 ° brix. It significantly differed from the treatment of NPK 16-16-16 fertilizer (3 g), which only reached 11.16 ° brix (Table 4). NPK 16-16-16 fertilizer contains nitrogen (N), phosphorus (P), and potassium (K), each of which has an essential role in the metabolic process of plants. Potassium is the main element that influences the synthesis and carbohydrate translocation, including simple sugars in plant tissues. Potassium plays a role in activating enzymes involved in photosynthesis and increasing sugar translocation to form starch, strengthening the size and quality of generative phase fruit, and adding sweetness so that the sugar content (brix) in the cob can increase (Putri & Saputro, 2024).

Applying 2.25 g of NPK 16-16-16 fertilizer has produced the highest sugar content in non-glutinous corn plants. The high sugar content is thought to be due to the sufficient nutrient content for the accumulation and distribution of photosynthesis results to the seed or cob. In this regard, research conducted by Patricia Kerawing et al. (2024) also emphasized that the greater the photosynthate that is channeled or translocated to the cob, the greater the food reserves that are translocated to the seeds, so that the weight of the seeds increases as well as the sugar content. In Patricia's research, the increase in corn yields occurred because the dose of nitrogen given to the plants was sufficient, resulting in fertile growth and helping to increase biomass production.

Giving too high a dose of NPK fertilizer, such as in the treatment of NPK fertilizer 16-16-16 dose (3 g), which produced the lowest sugar content, namely 11.16 ° brix. Low sugar content is caused by excess nitrogen, which can encourage excessive vegetative growth, thereby diverting plant energy sources from sugar synthesis to forming leaf and stem tissue. Excess nitrogen can reduce the efficiency of potassium utilization in plants, causing lower sugar accumulation. Applying NPK fertilizer 16-16-16 in a reasonably high dose, such as (3 g), can cause excess nitrogen, which triggers excessive vegetative growth and reduces sugar accumulation in seeds (Rohmaniya et al., 2023).

This study explains that the treatment of liquid organic fertilizer combined with NPK 16-16-16 fertilizer directly interacts with the sugar content parameters of glutinous corn plants (Table 5). The sugar content in the fruit is an indicator of the level of sweetness of the fruit. The combination of liquid organic fertilizer treatment of 6 ml/l and NPK 16-16-16 fertilizer 3.75 g/plant produced the highest sugar content of glutinous corn of 12.09 ° brix and was significantly different from other treatments. This shows a positive interaction between the two types of fertilizers at high doses, where NPK fertilizer provides macronutrients (N, P, and K), essential for plant metabolism processes. In contrast, liquid organic fertilizer helps increase the efficiency of nutrient absorption and improves soil microbiological conditions.

NPK fertilizer contains macro elements N (16%), P (16%), and K (16%), which corn plants very much need during the generative period. In addition, liquid organic fertilizer contains several micro elements and plant growth regulators (ZPT) such as auxins and gibberellins that help photosynthesis and form sugar compounds. Liquid organic fertilizers play a role in helping to provide macro and micro nutrients needed by corn plants during the vegetative and generative periods. Liquid organic fertilizers increase soil microbial activity and nutrient absorption efficiency, while

NPK fertilizers provide macronutrients essential for plant metabolism. The interaction between the two can increase the synthesis and accumulation of sugar in corn seeds, thereby helping to improve the sugar content in corn (Puspadewi et al., 2016).

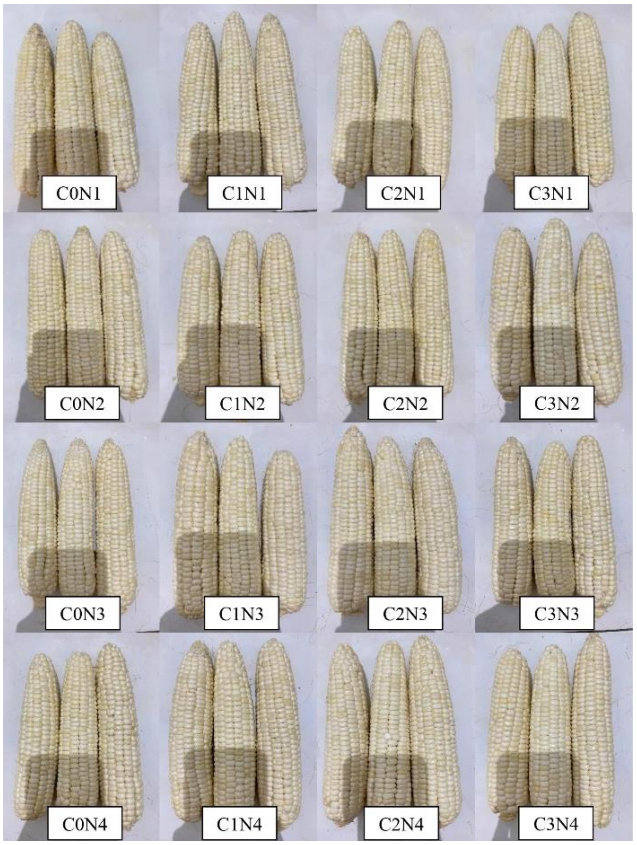

Figure 2. Samples of Glutinous Corn Cobs Between Treatments

Table 5. Average Sugar Content of Glutinous Corn Plants in Combination of Liquid Organic Fertilizer and NPK 16-16-16 Fertilizer Treatments

Average Sugar Content of Glutinous Corn (% brix)				
NPK Fertilizer Dosage 16-16-16	**Liquid Organic Fertilizer Dosage**			
	C0 (No Grant)	**C1 (2 ml/l)**	**C2 (4 ml/l)**	**C3 (6 ml/l)**
N1 (4.5 g)	11.24 ± 0.33 ab	11.17 ± 0.32 ab	11.49 ± 0.16 ab	11.76 ± 0.12 ab
N2 (2.25 g)	11.87 ± 0.44 ab	11.87 ± 0.47 ab	11.47 ± 0.38 ab	11.64 ± 0.12 ab
N3 (3 g)	11.36 ± 0.29 ab	11.49 ± 0.08 ab	11.27 ± 0.04 ab	10.53 ± 0.44 a
N4 (3.75 g)	10.84 ± 0.29 ab	11.11 ± 0.47 ab	11.49 ± 0.52 ab	12.09 ± 0.10 b
BNJ 5%	1.37			

Note: Numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

The combination of 6 ml/l liquid organic fertilizer and high-dose 3.75 g NPK 16-16-16 fertilizer increased the sugar content of glutinous corn plants. The high sugar content is thought to be because when entering the generative phase, high doses are needed; the older the age of the plant, the better the root system has developed, so the plant can more easily absorb the nutrients contained in the NPK 16-16-16 fertilizer. This finding aligns with research conducted by Nazirah (2025), which explains that giving high doses of NPK fertilizer accompanied by pruning in the generative phase can increase carbohydrate allocation in corn cobs, resulting in a larger corn cob weight and higher sugar content.

4. Conclusion

The results of this study indicate that a combination of 6 ml/l of liquid organic fertilizer and 3.75 g of NPK 16-16-16 fertilizer produced the highest sugar content in glutinous corn, measuring 12.09° Brix, which was significantly different from other treatments. Interestingly, the treatment without liquid organic fertilizer (0 ml/l) yielded the best results in terms of cob weight without husks, reaching 211.22 g. A single application of 2.25 g of NPK 16-16-16 fertilizer resulted in optimal outcomes for the length of glutinous corn plants at 14 days after planting (DAP) and for the sugar content of the corn. Additionally, the treatment with 3.75 g of NPK 16-16-16 fertilizer produced

the best results for the length of glutinous corn plants at 42 DAP. For future research focused on enhancing the sugar content of glutinous corn, it is recommended to utilize a combination of 6 ml/l of liquid organic fertilizer and 3.75 g of NPK fertilizer. However, to achieve optimal weight in corn cobs without husks, applying NPK fertilizer alone, without the addition of liquid organic fertilizer, is preferred. Further studies are necessary to assess the effects of a broader range of liquid organic fertilizer doses and to conduct an economic efficiency analysis of the fertilizer combinations employed.

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