

Response of Sweet Corn Growth, Yield, and Soil Chemical Properties to Organic and Inorganic Fertilizer Application in Alfisols

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Abstract

Sweet corn (*Zea mays saccharata*) is a horticultural commodity with high economic value and increasing market demand in Indonesia. However, national sweet corn productivity remains low compared to its genetic potential due to limited soil fertility, especially in Alfisols. To overcome this issue, this study aims to examine the effect of various fertilizers on the growth and yield of sweet corn, as well as changes in the chemical properties of Alfisols. The research method employed a completely randomized design (CRD) with a single factor and four treatments: control (without additional fertilizer), NPK 15-15-15 fertilizer, cow manure, and a combination of NPK 15-15-15 fertilizer and cow manure, each replicated three times. Plant growth and yield data (plant height, stem diameter, leaf number, ear weight, ear number, ear diameter, husked ear weight, and fresh weight) and soil chemical properties (pH, organic C, N, P, K) were analyzed using ANOVA followed by a 5% DMRT. The results showed that the combination of NPK 15-15-15 and cow manure produced the best growth and yield with an average plant height of 183.5 cm and ear length of 35 cm. These findings indicate that the combination of organic and inorganic fertilizers has the potential to improve sweet corn productivity and contribute to the soil's chemical quality in Alfisols.

1. Introduction

Sweet corn (*Zea mays saccharata*) is a horticultural commodity with high economic value and is widely favored in Indonesia for both household consumption and the food industry. Indonesia's favorable geographic and climatic conditions allow for widespread development of this commodity in various regions. However, national production of sweet corn still faces multiple challenges that affect yield stability and harvest quality. According to data from Badan Pusat Statistik (2024), the national corn harvest area in 2023 was approximately 2.48 million hectares, with a production of 14.77 million tons, indicating a decline from previous years. This decline reflects challenges in production. Various factors, including nutrient content and organic matter, can influence sweet corn productivity (Septiana et al., 2023).

Alfisols are a soil order commonly found in Indonesia. However, many Alfisols used for agricultural purposes exhibit relatively low soil fertility. It is characterized by its brown to red color, clayey texture, and base saturation

greater than 35%. Alfisols are widely used in agriculture due to their potential. However, Alfisols present challenges if not managed adequately during cultivation, from planting to harvest. These challenges include low Cation Exchange Capacity (CEC) and low total nitrogen, resulting in limited availability of plant nutrients (Supriyono et al., 2022). Alfisols also have low organic C content and poor drainage (Subhan et al., 2025). Therefore, the nutrient requirements for plant growth must be met through fertilization.

Fertilizer plays a crucial role in increasing the nutrient content of corn, improving soil structure, and enhancing crop quality after harvest. Fertilization is necessary because naturally occurring nutrients cannot fully meet a plant's nutrient requirements (Sriwahyuni and Parmila, 2019). Proper fertilization during sweet corn cultivation can improve production quality, which includes both organic and inorganic applications. Manure application increased the height of corn plants due to the increased N nutrient content, allowing the plant roots to develop better and absorb more nutrients (Thamrin and Hama, 2022). The application of organic fertilizers plays a crucial role in improving soil fertility, increasing soil pH, and creating a more favorable root environment for corn growth in Podzolic soil (Rusdiana et al., 2024). The application of various types of organic fertilizers has a significant effect on increasing pH, CEC, N availability, dry weight, and N absorption in corn plants compared to without organic fertilizer treatment in Podzolic soil (Febriani et al., 2023). The integration of organic fertilizers with inorganic nutrients (N, P, K) enhances maize growth, including improvements in plant height, leaf number, and stem diameter in Alfisols (Syamsiyah et al., 2021). The application of lime, NPK fertilizer, and organic fertilizer decreased the availability of Al and Fe, thereby increasing the availability of N, P, and K and promoting corn growth in post-mining land (Hasan et al., 2024).

Although previous research has studied different types of fertilizers for various kinds of soil, there is still limited information about how organic and inorganic fertilizers affect sweet corn growth and yield, as well as soil properties in Alfisols. Alfisols in Jumantono are generally characterized by low soil fertility. According to Hadiwiyono et al. (2023), Alfisol soils in Jumantono have an average soil pH of 5.79, indicating slightly acidic conditions. The organic matter content in this area is only 1.303%, which is classified as very low. In addition, the CEC ranges from 6.27 to 7.48 cmol(+) kg⁻¹, also indicating low nutrient retention capacity. These conditions are associated with limited mineral reserves and advanced soil weathering, resulting in frequent nutrient deficiencies, particularly in sulfur (S), organic carbon, and total nitrogen. Such constraints reduce fertilizer use efficiency, especially when inorganic fertilizers are applied without improving soil quality. Therefore, the application of organic fertilizers and their combination with inorganic fertilizers was evaluated to address the fertility limitations of Alfisols in Jumantono. Research by Syamsiyah et al. (2023) investigated the impact of organic and inorganic fertilizers on the physical properties of Alfisols and the growth of hybrid corn plants, specifically sweet corn, as well as the soil's chemical properties. Further research is needed to understand how sweet corn responds to various fertilizers, including organic, inorganic, and combinations. Such research helps to improve crop yield in suboptimal soil, such as Alfisols.

This study examined the effect of different fertilizer applications on sweet corn growth and the chemical properties of Alfisols. The objectives of this study were (1) to examine the growth and yield responses of sweet corn plants to various fertilizer treatments, and (2) to evaluate changes in the chemical properties of Alfisols as a result of the fertilizer treatments. The results of this study are expected to provide scientific information that can serve as a basis for determining appropriate and sustainable fertilization strategies for agricultural lands with limited fertility.

2. Research Methods

2.1. Research Location

The research was conducted from February to June 2025 in Jumantono, Karanganyar, Central Java, Indonesia, geographically located at 7°37'47.48"S and 110°56'52.39"E, as shown in Figure 1. The soil type at the research site is Alfisols, characterized by an argillic subhorizon. The geological formation in the research area is Qlla (Quarter Lawu Lava Flow). These consist of andesite, basalt, and pumice (Portal Data Jawa Tengah, 2022), forming thick, high-clay-content soil with a slightly acidic pH and low organic matter (Khairani et al., 2010).

2.2. Treatments and Management

A single factor with four treatments was applied using a completely randomized design (CRD) to examine the experiment, specifically the type of fertilizer. Additionally, all treatments used baseline fertilization in the form of urea at a 300 kg ha⁻¹ dose. Research consisted of four treatment levels: control (only urea, no additional fertilizer) (A), Urea + NPK 15-15-15 fertilizer (B), Urea + cow manure (C), and Urea + a combination of NPK 15-15-15 fertilizer and cow manure (D). Each treatment was replicated three times. Observations were made in a 2×3 m experimental plot. Treatment B used a 300 kg ha⁻¹ dose, thus 180 grams per plot. Treatment C used a 10 tons ha⁻¹ dose, therefore 6 kg per plot. Treatment D used half NPK and half organic, thus 90 grams of NPK and 3 kg of cow manure. All fertilizers were commercial fertilizers.

Research began with soil tilling to achieve a desirable structure and aggregation. After that, fertilizer was applied in the morning via the broadcasting method, by spreading it at a depth of 5-10 cm around the corn plant on the soil surface. For organic fertilizer, application was conducted at 0 days after planting (DAP) using the incorporation method, where cow manure was applied to the surface and then mixed with the soil. Urea was surface-applied in two split applications at 0 and 14 DAP at a rate of 90 g plot⁻¹ per application. NPK 15-15-15 fertilizer was applied at 14 and 28 DAP at the same rate (90 g plot⁻¹ per application). A soil sample was taken from the rhizosphere (5 cm around the plant). The sweet corn used here was the Talenta breed, planted with a 25×70 cm distance, resulting in 32 plants per plot. Corn was harvested at 70 days after planting.

The observation data included the growth of sweet corn plants (plant height, stem diameter, leaf number, ear length, ear diameter, ear number, husked ear weight, and plant fresh weight) as well as soil chemical properties (pH, organic C content, total nitrogen, available phosphate, and available potassium). Plant height, stem diameter, ear diameter, and ear length were measured using a morphometric method by measuring with a ruler. Leaf number and ear number were measured manually by counting the fully developed leaves and ears. Husked ear weight and fresh weight were measured using a gravimetric method with a digital scale. Soil pH was analysed by the Electrometry method, organic C content by the Walkley-Black method, total Nitrogen by the Kjeldahl method, available phosphate, and available potassium using 25% HCl extraction (Balai Pengujian Standar Instrumen Tanah dan Pupuk, 2023).

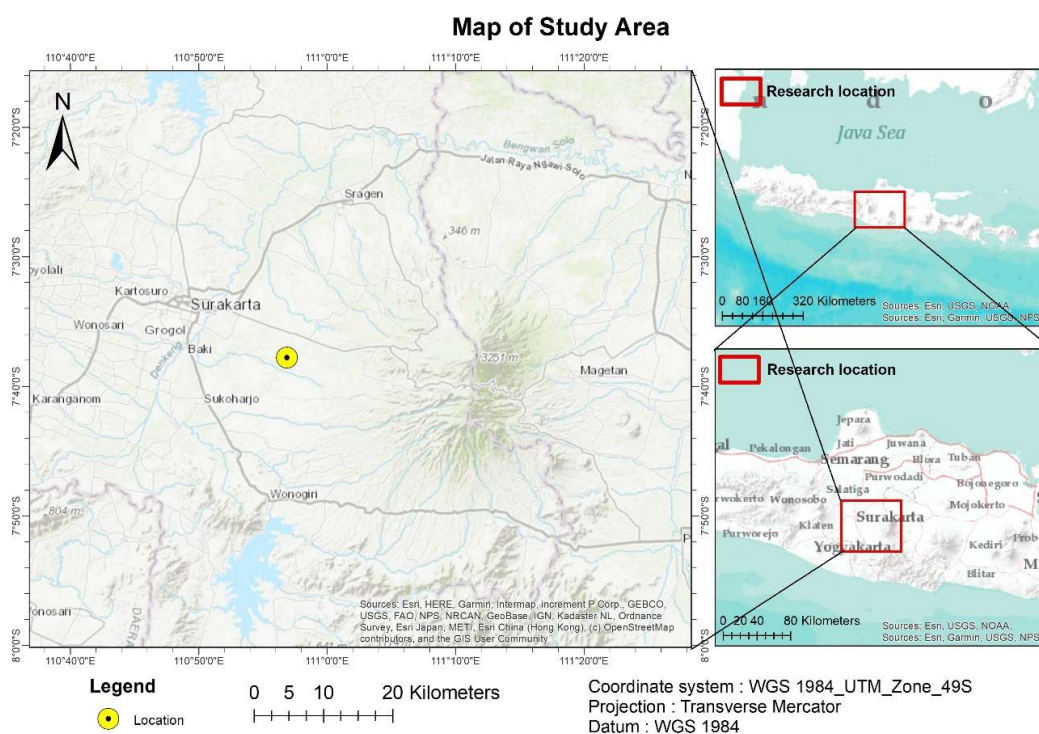


Figure 1. Map of the research area location in Jumantono District, Karanganyar Regency, Central Java

2.3. Data Analysis

The obtained data were analyzed using analysis of variance (ANOVA) to determine the effect of treatments on the observed variables. If significant differences were detected, the analysis was continued with a Duncan Multiple Range Test (DMRT) at the 5% significance level to distinguish differences among treatments. A linear regression analysis was then performed to determine the relationship between soil chemical properties (pH, N, P, K, and organic carbon) and sweet corn growth and yield.

3. Results and Discussion

3.1. Growth and Yield of Sweet Corn Under Various Fertilizer Treatments

Only two of the eight plant parameters showed significant results: plant height and ear length (Table 1). All other parameters yielded varying results, although none were statistically significant.

Table 1. Results of ANOVA of sweet corn growth parameters in various fertilizer treatments

Parameter	P value	Results
Plant height	0.000	Significant
Stem diameter	0.211	Not significant
Leaf number	0.088	Marginally significant
Ear length	0.000	Significant
Ear diameter	0.917	Not significant
Ear number	0.059	Marginally significant
Husked ear weight	0.480	Not significant
Fresh weight	0.508	Not significant

Table 2. Results of DMRT on the average height of sweet corn plants in various fertilizer treatments

Treatment	Average Plant Height (cm)	DMRT Notation
A	127.64 ± 4.82	b
B	172.70 ± 6.47	a
C	167.75 ± 5.20	a
D	183.53 ± 5.47	a

Notes: Different lowercase letters in row and column indicate significant differences at 5% level DMRT

The DMRT test results in Table 2 showed that treatment D (combination of NPK + cow manure) produced the highest plant height, namely 183.5 cm, and was significantly different from the control (127.6 cm). Treatments B (NPK) and C (cow manure) were grouped with D, indicating that both were able to increase plant growth, although not as effectively as the combination treatment. The combination of inorganic and organic fertilizers had a dual effect: rapid nutrient fulfillment and improved soil properties. This is supported by Surtinah (2020), who states that inorganic fertilizers can provide nutrients according to the growth phase. In addition, Adzikro et al. (2025) and Yu et al. (2025) explain that the supply of organic matter increases the activity of soil microorganisms, supports the soil ecosystem, enhances decomposition, and facilitates the release of nutrients into the soil.

Table 3. Results of DMRT on the ear length of sweet corn in various fertilizer treatments

Treatment	Average Ear Length (cm)	DMRT Notation
A	28.71 ± 1.16	c
B	32.42 ± 0.28	b
C	31.43 ± 0.61	b
D	35.00 ± 0.43	a

Notes: Different lowercase letters in row and column indicate significant differences at 5% level DMRT

Treatment D also produced the longest ear length, with an average of 35 cm, which was significantly different from the other treatments (Table 3). Treatments B and C formed an intermediate group with an average of 32.4 cm and 31.4 cm, respectively, while the control (A) produced the shortest ear with an average of 28.7 cm. These results suggest that fertilization has a significant impact on ear size. According to Yoskader et al. (2023), a balanced N, P, and K content in fertilizer affects the yield of sweet corn. Furthermore, Surtinah (2020) stated that fertilizers with P and K content play an important role in metabolism and photosynthesis, ultimately increasing crop yields.

Table 4. Linear regression results between plant height (X1) and ear length (X2) with treatment (Y)

Variables	Coefficient	Std. Error	t-count	P-value
Constant (a)	-5,524	1,329	-4.157	0.000
Plant Height (X1)	0.020	0.006	3,449	0.000
Length of Ear (X2)	0.151	0.050	3,005	0.000

Notes: R Square (R²) = 0.591

The regression analysis results are presented in Table 4. Plant height (X1) and ear length (X2) significantly influence yield with a coefficient of determination (R²) of 0.591. These indicate that two variables can explain 59.1% of the variation in sweet corn yield, while other factors outside these two variables influence the remaining 40.9%. The positive coefficient obtained confirms that the increase in plant height and ear length is associated with an increase in sweet corn yield.

3.1.1 Plant Growth

Sweet corn growth results are shown in Figure 2 (1-3). All treatments showed different than control (A) although only plant height was significant ($p < 0.05$). Thus, DMRT was only applied in plant height results.

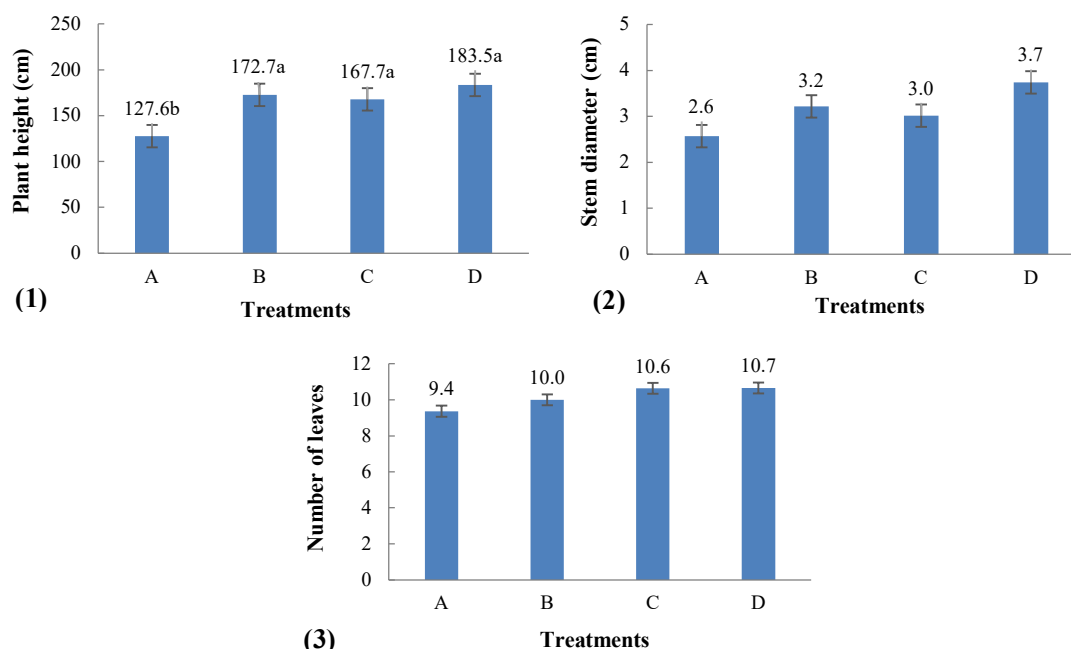


Figure 2. Average plant height (1), stem diameter (2), and leaf number (3) of sweet corn in various fertilizer treatments. Different lowercase letters on bars indicate significant differences at 5% level DMRT

Treatment A was the control treatment, which received only basic fertilizer (urea) at 180 grams per 6 m², applied in two stages: at planting and 14 days after planting (DAP). Corn plants in this treatment had an average height of 127.6 cm, a stem diameter of 2.6 cm, and a leaf number of 9.4. Treatment B received basic urea (180 grams per 6 m²) and an additional NPK fertilizer at 180 grams per 6 m², applied in two stages at 14 and 28 DAP. The plants in this treatment had an average height of 172.7 cm, a stem diameter of 3.2 cm, and a leaf number of 10. Treatment C received basic fertilizer urea (180 grams per 6 m²) along with 6 kg of cow manure per 6 m², applied once before planting. The plants in this treatment had an average plant height of 167.7 cm, a stem diameter of 3 cm, and a leaf number of 10.6. Treatment D received basic fertilizer (180 grams of urea per 6 m²), supplemented with 3 kg of cow manure and 90 grams of NPK fertilizer per 6 m², applied in two stages at 14 and 28 DAP. The plants in this treatment had an average height of 183.5 cm, a stem diameter of 3.7 cm, and a leaf number of 10.7.

Applying different types of fertilizer significantly affected the growth of sweet corn plants. Treatment D produced the best growth, with an average height of 183.5 cm, a stem diameter of 3.7 cm, and 10.7 leaves (Yuniarti et al., 2019). Balanced fertilization is crucial for increasing crop yields. The synergy between organic and inorganic fertilizers provides nutrients in a readily available form while improving the physical properties of the soil, allowing plants to absorb nitrogen and phosphorus more efficiently (Wang et al., 2025).

Treatment B also showed high growth, with an average plant height of 172.7 cm, a stem diameter of 3.2 cm, and 10 leaves. Rapidly available nutrients from NPK fertilizer can accelerate stem and leaf formation, but long-term soil fertility improvements remain limited without the proper addition of organic matter (Khairunisa, 2015). The weakness of inorganic fertilizers is that they are easily leached into the lower soil layers. Applying pure inorganic fertilizer increases the rate of vegetative growth. Still, its efficiency decreases in soils with low organic matter content because nutrients are easily leached once they are dissolved in the soil (Adugna, 2023).

Treatment C produced a plant height of 167.7 cm, a stem diameter of 3.0 cm, and 10.6 leaves. Organic fertilizer enhances soil structure and provides a broader range of nutrients. However, the amount of nutrients in organic fertilizer is lower, so is the nutrient release. According to Sharma and Chetani (2017), organic fertilizers result from microbiological activity breaking down organic matter and have slow-release characteristics. This results in lower vegetative growth than treatments involving inorganic fertilizers.

The lowest growth was observed in treatment A, with a plant height of 127.6 cm, a stem diameter of 2.6 cm, and 9 leaves. This is due to a lack of P and K, which play an essential role in plant growth. According to Akbari

et al. (2022), potassium deficiency in plants inhibits photosynthesis, while phosphorus deficiency limits cell division. Although urea-based fertilizer provides sufficient nitrogen during early growth, the lack of additional phosphorus and potassium restricts the formation of new vegetative tissue. Nitrogen availability does support stem elongation, but leaf growth and stem enlargement require an adequate balance of phosphorus and potassium.

Sweet corn growth showed no significant differences in stem diameter or leaf number due to its genetic and environmental factors (Oktaviani et al., 2020). Each type of corn has a unique genotype that influences its ecological adaptability, response to fertilization, and resistance to pests and diseases. Furthermore, different plot positions influence growth results. According to Lupiana et al. (2023), the position of the plant determines the level of sunlight, which in turn influences the rate of photosynthesis and ultimately affects plant growth.

3.1.2 Crop yield

Sweet corn yield parameters are shown in Figure 3 (1-5). All treatments showed different than control (A) although only ear length was significant different ($p < 0.05$). Thus, DMRT was only applied in ear length results.

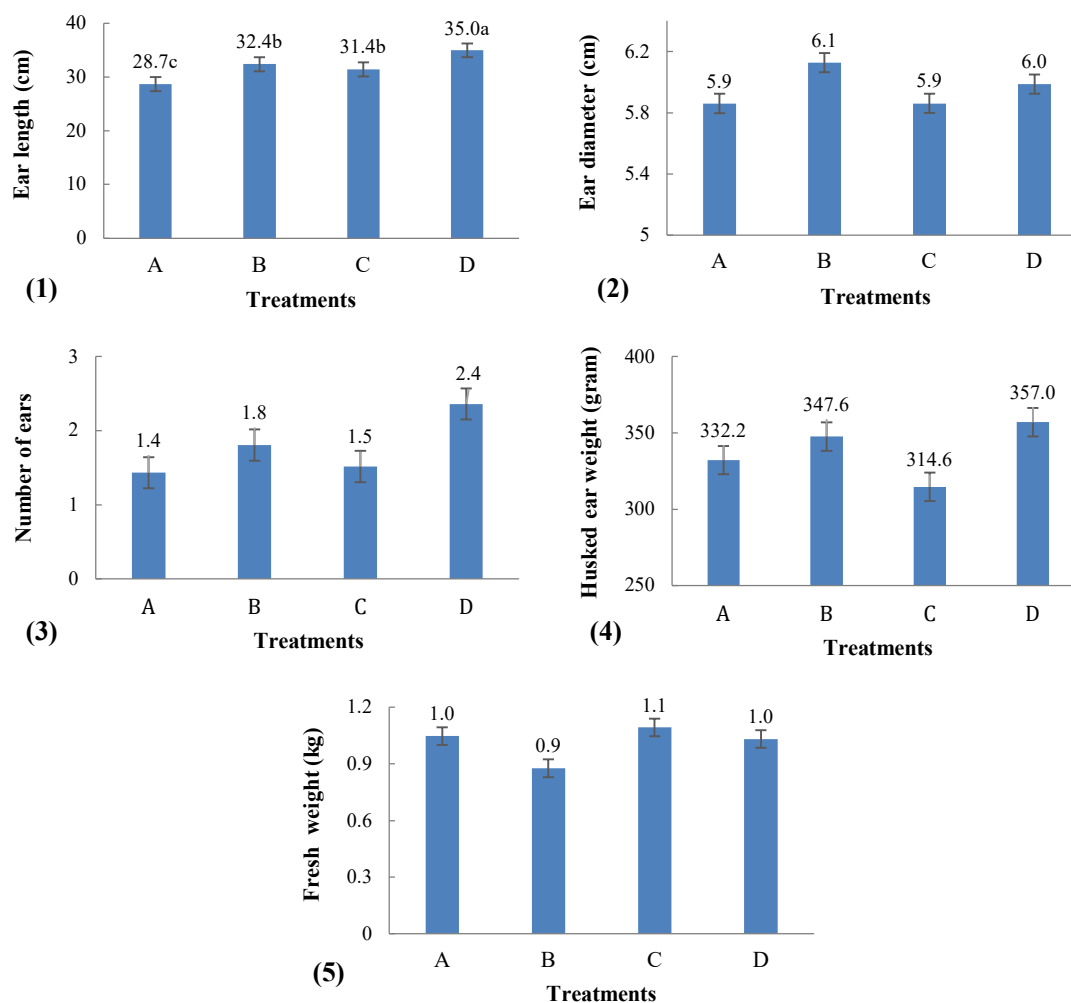


Figure 3. Average ear length (1), ear diameter (2), ear number (3), husked ear weight (4), fresh weight (5) in various fertilizer treatments. Different lowercase letters on bars indicate significant differences at 5% level DMRT

Different fertilizer treatments affected the yields of sweet corn. Treatment D produced the highest yield, with an average ear length of 35 cm, an ear number of 2.4, a husked ear weight of 357 grams, an ear diameter of 6 cm, and a fresh weight of 1 kg. Combining organic and inorganic fertilizers provides readily available macronutrients while enhancing the soil's capacity to retain water and nutrients. According to Zuhaida and Kurniawan (2018), one of the roles of organic matter is to increase fertilizer availability and efficiency. In addition, Syamsiyah et al. (2023)

stated that the combination dose of $\frac{1}{2}$ NPK and 1 organic fertilizer significantly increased soil C-organic, total N, available P, and CEC. P is important in photosynthesis, thus ultimately increasing plant yield (Pereira et al., 2020).

Treatment B produced an ear length of 32.4 cm, an ear number of 1.8, an ear diameter of 6.1 cm, a husked ear weight of 347.6 grams, with a fresh weight of 0.9 kg. Although the results of this treatment were relatively high compared to the other two treatments, they remained lower than those of treatment D. This is because treatment D used cow manure with a high organic matter content, which increased soil CEC, enhancing essential nutrient retention and release for plants. According to Putra et al. (2024), the soil CEC is strongly influenced by soil organic matter, the higher the organic matter content, the higher the CEC. In treatment B, the rapid availability of nutrients from NPK fertilizer accelerated the growth of generative tissues. However, without a supply of organic matter, nutrient uptake efficiency is likely to be suboptimal due to leaching.

Treatment C produced an ear length of 31.4 cm, ear number of 1.5, a ear diameter of 5.9 cm, and husked ear weight of 314.6 grams, with a fresh weight of 1.1 kg. Organic fertilizer increased vegetative biomass, indicated by relatively high fresh weight. However, slow and limited nutrient release resulted in limited ear formation in the generative phase. According to Siwanto et al. (2015), organic fertilizer should not be a substitute for inorganic fertilizer, but rather a complement. Therefore, organic fertilizer should be integrated with inorganic fertilizer to enhance soil and plant productivity, adopting a sustainable approach to agriculture.

The lowest yield was in treatment A, with an ear length of 28.7 cm, ear number 1.4, husked ear weight of 322.2 grams, ear diameter of 5.9 cm, and fresh weight of 1.0 kg. Urea-based fertilizer provided nitrogen to support biomass formation, but without additional phosphorus and potassium, generative yield was limited. According to Zakiah et al. (2019), the nutrients required for plant growth and development are inseparable from three nutrients: nitrogen (N), phosphorus (P), and potassium (K). These three nutrients have mutually supportive functions. Yoskader et al. (2023) added that NPK fertilizer affects corn flower and ear weight.

3.2. Effect of Soil Chemical Properties on Plant Growth in Various Fertilizer Treatments

Response of soil chemical properties to fertilizer application are shown in Figure 4 (1-5) but since no results were significant ($p > 0.05$), DMRT was not applied. Soil chemical properties play a significant role in determining the effectiveness of different fertilizers on sweet corn growth in Alfisols. The control treatment (A) had a neutral soil pH (7.07), relatively high organic carbon content (1.32%), and a total nitrogen level of 0.46%. However, despite these generally favorable soil properties, plants grown in control treatment showed the lowest growth and shortest ear length. This suggests that overall soil chemical status alone was insufficient to support optimal plant performance, and that nutrient availability, balance, or release dynamics in the amended treatments played a more critical role in promoting growth and ear development. This is explained by Awwal et al. (2025), who suggest that meeting plant needs over time with nutrient release is more critical in supporting plant growth than maintaining a static soil nutrient status. In addition, relatively lower P in treatment A contributed to lower growth and ear development. This finding is supported by Ullah et al. (2023), who found that supplementing P increased ear length and weight in sweet corn, compared to the untreated control. Furthermore, insufficient P supply during a critical time in growth resulted in lower yields, caused by inhibited energy transfer, reduced shoot and root growth, and decreased photosynthesis efficiency (Ampong et al., 2024).

NPK treatment (B) resulted in a lower pH than the control (A), with the soil pH tending to be slightly acidic (6.76), higher organic carbon (1.42%), and higher total nitrogen (0.79%). NPK fertilizer contains Nitrate (NO_3^-) and/or Ammonium (NH_4^+), which is highly soluble and increases the total N in soil immediately (Sara et al., 2024). NPK fertilizer utilization decreases soil pH because of the nitrification of NH_4^+ . According to Tkaczyk et al. (2020), the nitrification of NH_4^+ to NO_3^- releases H^+ into the soil, resulting in a decrease in soil pH due to the increased H^+ ions in the soil.

The cow manure treatment (C) resulted in a pH of 6.51, organic carbon of 1.41%, total nitrogen of 0.41%, and higher phosphate (2.67 ppm). Nutrient availability under this treatment was limited due to the slow decomposition of organic fertilizer, resulting in suboptimal generative growth (ear length and grain filling). Treatment C showed suboptimal growth, despite the higher amount of organic fertilizer, due to less favorable soil chemical properties. The organic carbon content of 1.41% and total nitrogen content of 0.41% indicated that the manure had not quickly decomposed, resulting in slow nutrient release. Yang et al. (2023) state that organic fertilizers take longer to mineralize and provide plant-available nutrients. This treatment resulted in available phosphorus levels of only 2.67 ppm and potassium levels of $0.13 \text{ cmol kg}^{-1}$, which are insufficient for plant availability (Putriani et al., 2022). Phosphorus is crucial for ear formation and grain filling, and its deficiency can result in suboptimal generative yields. Potassium availability is mid to low, which is caused by a soil pH of 6.51, leading to the unavailability of some elements, including potassium, due to the high amount of Aluminum that competes with other cations like potassium (Legesse et al., 2017).

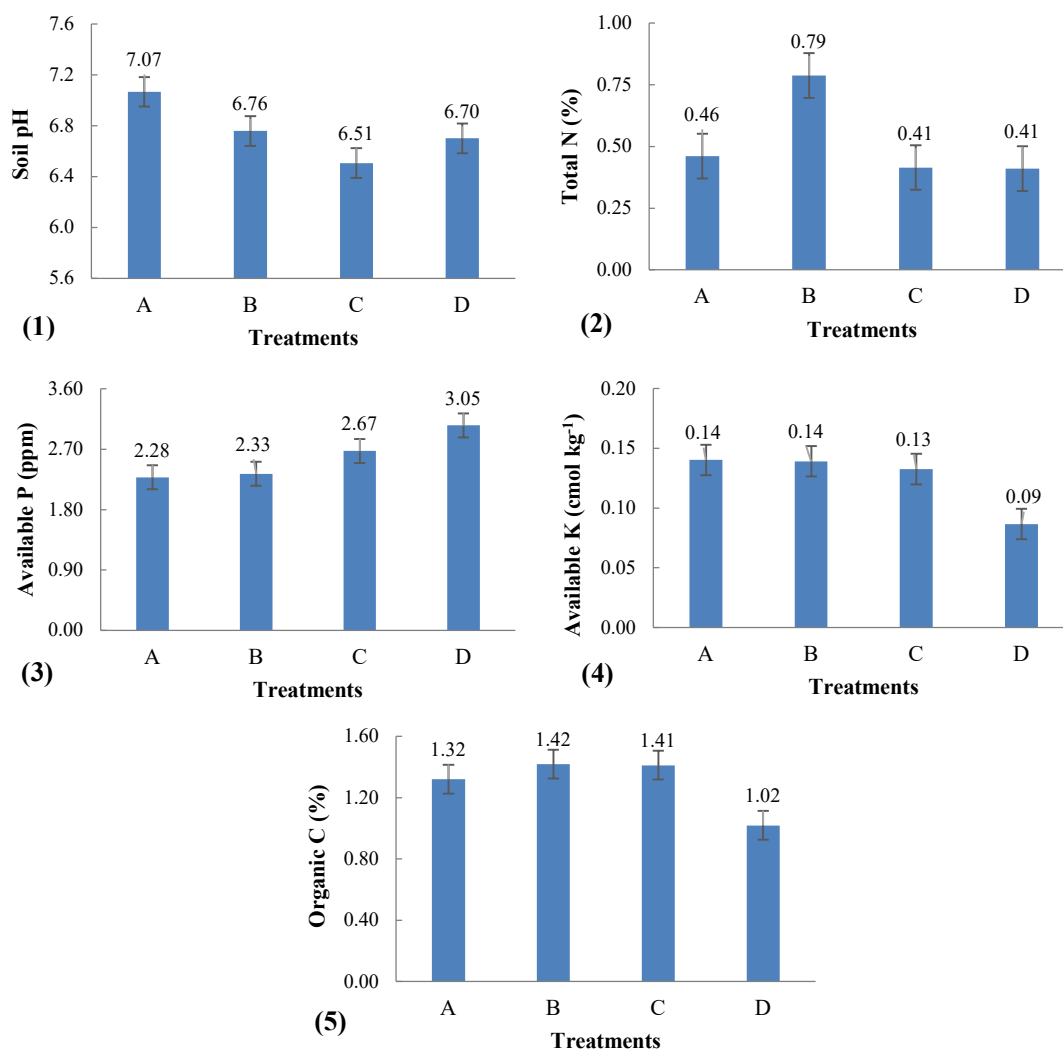


Figure 4. Response of soil chemical properties: soil pH (1), total N (2), available P (3), available K (4), and organic C (5) in various fertilizer treatments in Alfisols. Different lowercase letters on bars indicate significant differences at 5% level DMRT

The combined treatment of NPK fertilizer and cow manure (D) resulted in a pH of 6.70, organic carbon of 1.02%, total nitrogen of 0.41%, and the highest available phosphorus of 3.05 ppm. This combination supported microbial activity and supplied both rapidly available nutrients from NPK and slow-release nutrients from manure. As a result, vegetative growth (height, diameter, and leaf number) and generative yields (ear weight, number of ears, and stalks) were more optimal than other treatments. According to Araujo et al. (2025), gradual fertilizer application has been shown to increase nutrient uptake efficiency, which aligns with the physiological needs of plants during growth. Soil analysis revealed a total nitrogen content of 0.41% and an available phosphorus level of 3.05 ppm, which is higher than that of treatment C. A soil pH of 6.70 is ideal for corn plants, allowing for more efficient nutrient uptake. Phosphorus has a very narrow pH range for absorption. At higher soil pH, phosphorus (P) is fixed by calcium (Ca), but at low pH, P is fixed by aluminum (Al) and iron (Fe); thus, a specific pH range is required for optimal P uptake (Pang et al., 2024). In addition, Wang et al. (2025) found that the combination of organic and inorganic fertilizers not only accelerates plant growth but also maintains long-term soil fertility. It explains why, despite the lower manure content in treatment D, growth yields remained higher, supported by the direct nutrient availability from NPK fertilizer and the contribution of organic matter, which maintains soil moisture and health.

4. Conclusion

This study demonstrates that fertilizer application has a significant impact on the growth and yield of sweet corn (*Zea mays saccharata*) and enhances the soil chemical properties of Alfisols. The combination of NPK fertilizer and cow manure (treatment D) produced the best growth, with a plant height of 183.53 cm and an ear length of 35.00 cm, which was significantly different from the control. This combination treatment also increased productivity, with an average ear weight of 357 g, and improved soil chemical properties, as indicated by increased available phosphorus (P) and soil pH. Thus, the simultaneous use of organic and inorganic fertilizers provides a positive synergy in providing readily available nutrients while improving soil quality. The results of this study confirm that a balanced fertilization strategy has the potential to increase sweet corn productivity and support long-term Alfisols fertility. Despite the positive outcome, this research has several limitations that open opportunities for further study. Future research is recommended to examine the long-term use of integrated fertilizers using a wider range of fertilizer types and dosages under different climatic conditions and crop types in Alfisols.

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