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# Potassium-Enriched Cattle Manure Fertilizer Improves Sweet Corn Growth, Yield, and Quality

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**Abstract**
Ultisol has low fertility, and inorganic fertilizer alone lowers soil quality and sweet corn quality. Beef cattle manure can be processed into potassium-enriched organic fertilizer. Objective: This study evaluated the effects of potassium-enriched cattle manure fertilizer, NPK fertilizer, and their combination on sweet corn growth, yield, and sugar content, and assessed whether the organic fertilizer could reduce NPK use. A factorial randomized block design with three replications was conducted from January to April 2026 on Ultisol in Padang Lawas, North Sumatra, Indonesia. The first factor was the organic fertilizer at 0, 15, 25, and 30 t/ha, and the second factor was NPK fertilizer at 0, 250, 300, and 350 kg/ha. Plant height, stem diameter, leaf number, ear weight, and sugar content were analyzed using analysis of variance and the least significant difference test at 5%. The organic fertilizer significantly improved all variables. NPK fertilizer significantly increased ear weight per plot and sugar content but did not affect vegetative growth. At 30 t/ha without NPK fertilizer, ear weight with husk (6.3 kg per plot) and sugar content (16.0%) were statistically equal to those of the best combinations. At 250 kg/ha NPK fertilizer, 30 t/ha of the organic fertilizer increased ear weight without husk by 119.2% and sugar content by 111.7% compared with no organic fertilizer. The organic fertilizer at 30 t/ha improved sweet corn growth, yield, and sugar content on Ultisol and may partially substitute for NPK fertilizer under the conditions tested.

**Keywords**— Cattle Manure; NPK Fertilizer; Potassium; Sweet Corn; Ultisol

## Introduction

Sweet corn (*Zea mays saccharata* Sturt) has become an attractive horticultural crop for farmers in Indonesia because of its sweet taste, high nutritional value, and relatively short growing period. Its productivity and kernel quality, however, depend strongly on soil fertility. Ultisol covers roughly 45 million hectares, about 25% of Indonesia's land area (Subagyo et al. 2004), and a recent review still reports 45.09 million hectares of Ultisol within 99.56 million hectares of acid upland soils (Kasno, 2019). These soils are an important resource for crop expansion, yet they are acidic, low in organic carbon, nitrogen, phosphorus, and potassium, and often high in aluminum saturation (Kasno, 2019). Continuous use of inorganic fertilizer without organic matter further degrades the physical, chemical, and biological properties of such soils, which reduces yield and fruit quality.

Organic fertilizer is one way to restore soil fertility and reduce dependence on inorganic fertilizers. Combining organic and inorganic fertilizers has been reported to raise sweet corn yield and improve fertilizer efficiency (Asbur et al. 2015; Sukmawati et al. 2025; Syahputra 2024). On acid upland soils, organic matter can also raise the effectiveness and efficiency of NPK fertilization (Kasno, 2019). Cattle manure is a widely available organic source. It is rich in organic matter and nutrients, and its use as fertilizer also reduces the environmental problems caused by livestock waste.

The beef cattle breeding installation in Tanjung Beringin Village, Padang Lawas Regency, North

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Sumatra, occupies 22 ha of Ultisol and can house up to 300 cattle. It currently produces about 10 tons of manure per week. At this rate, the installation generates roughly 520 tons of fresh manure per year (10 tons × 52 weeks), which must be managed whether or not it is used. Processing the manure at its source and applying it on the surrounding Ultisol offers three practical benefits: it reduces the need to buy and transport fertilizer, it limits the nutrient losses and pollution risks of stockpiling untreated manure, and it returns organic matter and nutrients to a soil that is low in both (Kasno, 2019). This links livestock and crop production in an integrated system and supports local agricultural management by turning a waste stream into a locally produced input.

Manure alone, however, often supplies limited potassium, whereas potassium is essential for the translocation of photosynthates and for sugar accumulation in sweet corn kernels (Arsyad et al. 2025; Mustaqim 2024; Paskalis 2024). Enriching manure with potassium before granulation may therefore combine the soil-improving effect of organic matter with the nutritional needs of sweet corn. We refer to this product as potassium-enriched cattle manure fertilizer, abbreviated as POSK from its Indonesian name (*pupuk organik limbah sapi plus K*).

Previous studies mostly tested raw cattle manure combined with NPK fertilizer (Asbur et al. 2015; Syahputra 2024) or potassium sources applied separately (Mustaqim 2024; Paskalis 2024; Usmadi 2023; Wibowo et al. 2017). As summarized in Table 1, none of the studies we identified evaluated a granulated cattle manure fertilizer enriched with potassium during processing, produced from waste at the site where it is used, together with graded NPK doses on Ultisol. It also remains unclear whether such a fertilizer can reduce the need for NPK fertilizer without sacrificing sweet corn yield and sugar content.

This study therefore aimed to determine the effects of POSK, NPK fertilizer, and their combination on the growth, yield, and sugar content of sweet corn grown on Ultisol, and to assess the potential of POSK to partially substitute NPK fertilizer. We hypothesized that POSK, NPK fertilizer, and their combination would each improve growth, yield, and sugar content.

## Literature Review

Three theoretical principles underpin this study. First, crop growth and yield depend on whether the supply of each nutrient is deficient, adequate, or excessive relative to crop demand (Johnson et al. 2022). On a nutrient-poor soil such as Ultisol, the response to added nutrients is therefore expected to be large when supply is low and to diminish as supply becomes adequate. Second, organic inputs and mineral fertilizer play complementary roles: mineral fertilizer supplies readily available nutrients, whereas organic inputs supply carbon and nutrients and improve soil conditions, and meta-analyses show that organic fertilizers, alone or combined with mineral fertilizers, increase soil organic carbon and can maintain or improve crop yield depending on soil and management conditions (Allam et al. 2022). Third, potassium is a quality element as well as a yield element, because it controls processes that determine how much of the assimilate produced by the leaves reaches the harvested organ.

Applied to the variables in the title, this framework operates through the soil and through the plant. Manure added to acidic soils can raise pH, reduce aluminum toxicity through the formation of aluminum–organic complexes, and increase organic matter and cation exchange capacity, which improves the conditions for root growth and nutrient uptake (Zhang et al. 2023). Potassium is not a structural component of plant tissue, but more than 60 enzymes depend on it for activation, and it regulates water balance in the plant (Johnson et al. 2022). In maize, potassium in the phloem also helps maintain the pressure that drives the transport of photoassimilates from the leaves to sinks such as the developing ear (Babst et al. 2022). Adequate potassium supply is therefore expected to support assimilate export to the ear, and thereby ear weight and kernel sweetness.

Combining these principles, a fertilizer that carries organic matter and potassium together (POSK) is

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expected to affect sweet corn through two linked pathways: an improved soil environment and nutrient supply that support vegetative growth, and a larger potassium supply that supports assimilate transport to the ear and sugar accumulation in the kernels. Because POSK and NPK fertilizer both supply nutrients, the response to NPK is expected to be large when POSK is absent and to diminish as POSK supply increases, which is the POSK × NPK interaction tested in this study. In this framework, plant height, stem diameter, and leaf number are responses to soil conditions and nutrient supply; ear weight is the yield response to assimilate production and its partitioning to the ear; and sugar content (% Brix) is the quality response to potassium supply.

Fermented cattle manure loses most of its pathogens and weed seeds and supplies organic matter and nutrients. (Saprudin 2024) reported that cattle manure fertilizer enriched with beneficial microbes exceeded the minimum nitrogen, phosphorus, and potassium contents set by the national organic fertilizer standard. (Abidin, 2023) showed that mixing manure with lignocellulosic materials, such as coconut fiber and rice straw, produced solid organic fertilizer whose moisture content and pH met the Indonesian national standard SNI 7763:2018. (Shobib 2023) emphasized that material composition and fermentation determine the physical and chemical stability of the final product. Field studies have shown that cattle manure influenced sweet corn growth and production (Dartius et al. 2012; Khan et al. 2021; Sunarni et al. 2023).

NPK fertilizer releases nutrients quickly, whereas organic fertilizer releases them gradually and improves soil conditions. Balanced use of both sources increased ear weight and quality of sweet corn compared with a single fertilizer (Asbur et al. 2015) , and the combination of cattle manure and NPK fertilizer improved sweet corn growth and production through better soil fertility and nutrient availability (Syahputra 2024) . The efficiency of combined manure and NPK fertilizer has also been evaluated by Sukmawati et al. (2025). NPK compound fertilizer supplies nitrogen, phosphorus, and potassium in one product. The NPK 15-15-15 used in this study contains 15% N, 15% $P_2O_5$, and 15% $K_2O$, so a dose of 300 kg/ha supplies 45 kg each of N, $P_2O_5$, and $K_2O$ per hectare. A dose of 300 kg/ha is commonly recommended for sweet corn (Simanjuntak 2021).

Potassium activates many enzymes and moves photosynthates to the ear, so potassium supply affects kernel sweetness. Potassium fertilizer significantly affected the sweetness of sweet corn (Arsyad et al. 2025; Paskalis 2024), and a potassium dose of 300 kg/ha gave the highest sweetness (% Brix) in one trial (Mustaqim 2024). Organic fertilizer combined with KCl also raised sweet corn yield (Aminah 2022).

To make the research gap explicit, Table 1 maps the closest studies on organic fertilizer, potassium, or their combination with NPK in sweet corn that reported growth, yield, or sweetness. The studies were selected from those cited in this paper and from one additional study found in a focused search of Indonesian and international journals (Wibowo et al. 2017). It is a focused mapping and not an exhaustive systematic review.

**Table 1. Studies On Organic and Potassium Fertilizers for Sweet Corn and the Position of This Study**

| Reference | Organic source | Inorganic / K source | Main finding reported |
|---|---|---|---|
| Asbur & Purwaningrum (2015) | Organic fertilizer (balanced) | Inorganic fertilizer | Balanced organic–inorganic fertilization increased ear weight and quality compared with a single fertilizer |
| Syahputra et al. (2024) | Cattle manure | NPK | Improved growth and production |

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| | | | |
|---|---|---|---|
| Sukmawati et al. (2025) | Manure | NPK Mutiara | Efficiency of the combined application evaluated |
| Dartius et al. (2012); Khan et al. (2021); Sunarni et al. (2023) | Cattle manure (alone, with ABG fertilizer, or with bio-urine) | None | Cattle manure influenced growth and production |
| Aminah et al. (2022) | Vermicompost | KCl | Combined application raised yield |
| Wibowo et al. (2017) | Chicken manure | KCl | KCl at 200 kg/ha raised sugar content to 17 °Brix |
| Mustaqim et al. (2024) | None | Potassium fertilizer | 300 kg/ha of potassium gave the highest sweetness (% Brix) |
| Arsyad et al. (2025); Paskalis et al. (2024) | None (liquid cattle-blood fertilizer in Paskalis et al.) | Potassium fertilizer, several sources | Potassium significantly affected sweetness |
| Usmadi et al. (2023) | None | Potassium with paclobutrazol | Growth and yield evaluated |
| **This study** | Granulated cattle manure enriched with KCl during processing (POSK), 0–30 t/ha | NPK 15-15-15, 0–350 kg/ha | Growth, yield, and sugar content on Ultisol |

*None = not applied. Findings are summarized from the cited studies.*

Three points follow from Table 1. First, organic and inorganic fertilizers applied together generally gave better yield or quality than a single source (Asbur et al. 2015; Sukmawati et al. 2025; Syahputra 2024), so manure plus NPK is the appropriate reference against which a new organic fertilizer should be compared. Second, potassium was reported to affect sweetness in several studies, but the response varied with the dose and the potassium source (Arsyad et al. 2025; Mustaqim 2024; Paskalis 2024; Wibowo et al. 2017), and in all of them potassium was applied as a separate input. Third, none of these studies tested potassium supplied inside a processed manure fertilizer together with graded NPK doses on Ultisol. It is therefore unknown whether such a product can deliver the sweetness benefit of potassium while reducing the NPK required.

These points determined the design of this study. POSK was applied at 0, 15, 25, and 30 t/ha to create a gradient of manure and potassium supply, and NPK at 0, 250, 300, and 350 kg/ha to bracket the recommended dose, so that the POSK × NPK interaction would show whether the response to NPK disappears when POSK supplies more nutrients. Growth, ear weight, and sugar content were chosen as indicators of vegetative growth, yield, and quality, as in the cited studies, and the three hypotheses stated above (effects of POSK, of NPK, and of their combination) follow from this reasoning.

## Research Method

### Experimental site and design

The experiment was conducted from January to April 2026 at the experimental field of the Beef Cattle Breeding Installation Unit, Tanjung Beringin Village, South Barumun District, Padang Lawas Regency, North Sumatra, Indonesia (420 m above sea level). The soil was an Ultisol. Soil nutrient analyses were carried out at the Soil Laboratory of the Agricultural Instrument Standardization Agency (BSIP), Pangkalan Masyhur, Medan. The planting material was an F1 hybrid sweet corn (trade name Exsotic Pertiwi).

This experiment employed a randomized complete block design (RCBD) with a factorial arrangement

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consisting of two factors and three replications (blocks). The first factor was POSK, with four levels: K0 (control), K1 (8.1 kg per plot, equivalent to 15 tons/ha), K2 (13.5 kg per plot, 25 tons/ha), and K3 (16.2 kg per plot, 30 tons/ha). The second factor was NPK fertilizer, also with four levels: N0 (control), N1 (135 g per plot, 250 kg/ha), N2 (162 g per plot, 300 kg/ha), and N3 (189 g per plot, 350 kg/ha). This 4 × 4 factorial design resulted in 16 treatment combinations and 48 experimental plots. Each plot measured 225 cm × 240 cm (5.4 m²) and contained 30 plants, with a planting distance of 60 cm × 30 cm. A spacing of 50 cm was maintained between plots, and 100 cm between blocks, resulting in a total of 1,440 plants. The NPK fertilizer used was NPK 15-15-15 (15% N, 15% $P_2O_5$, 15% $K_2O$). The dosages were determined based on the generally recommended rate of 300 kg/ha (Simanjuntak, 2021): N2 represents the recommended dosage, while N1 (250 kg/ha) is 17% below this rate, and N3 (350 kg/ha) is 17% above it. Thus, the plant response to reduced, recommended, and increased NPK application rates can be compared against conditions with no NPK (N0) or with the application of POSK. These three dosage levels supply 37.5 kg, 45 kg, and 52.5 kg of N, $P_2O_5$, and $K_2O$ per hectare, respectively.

The statistical model was

$$Y_{ijk} = \mu + \rho_i + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk},$$

Where $Y_{ijk}$ is the observation in block *i* receiving POSK level *j* and NPK level *k*, $\mu$ is the overall mean, $\rho_i$ is the block effect, $\alpha_j$ is the POSK effect, $\beta_k$ is the NPK effect, $(\alpha\beta)_{jk}$ is the interaction effect, and $\varepsilon_{ijk}$ is the experimental error.

**Sample plants**

The plot, which contained 30 plants, was the experimental unit, and the 48 plots were the units of replication. Because it was not practical to measure every plant in every plot at weekly intervals, five plants per plot (16.7% of the plants in the plot; 240 plants in total) were observed as sub-samples. The five plants were selected by simple random sampling without replacement from the 30 plants in each plot, so that every plant had the same chance of being chosen and the choice was not influenced by plant size or position. Each selected plant was marked with a stake 5 cm above the soil surface so that the same plants were measured at every observation and at harvest.

The number of sample plants was based on two considerations. First, the number of plants needed to represent a plot depends on the plant-to-plant variability within the plot and on the precision required for the mean (Gomez 1984) ; the mean of five plants is less affected by a single abnormal plant than the mean of one or two plants. Second, five plants per plot was the number that could be measured weekly and non-destructively for three growth variables on five dates and weighed individually at harvest. The sample size was not derived from a formal calculation based on a pilot variance estimate. The values of the five sample plants were averaged to give one value per plot, and this plot mean was used in the analysis of variance, so that the sample plants were not treated as independent replicates. Variables recorded for the whole plot (ear weight per plot) used all plants in the plot, and sample plants were used only for variables that could not practically be recorded on all 30 plants.

**Preparation of POSK**

POSK was prepared from 200 kg of cattle manure and 5 kg of KCl. The materials were piled into a compost mound and mixed evenly. The mixture was fermented for 30–60 days at 40–60 °C and 50–60% moisture and was turned every 5–7 days, an approach consistent with those reported for manure-based organic fertilizers (Saprudin 2024; Shobib 2023). Mature compost, indicated by a neutral odor and crumbly texture, was dried, sieved, granulated, and packed (Figure 1).

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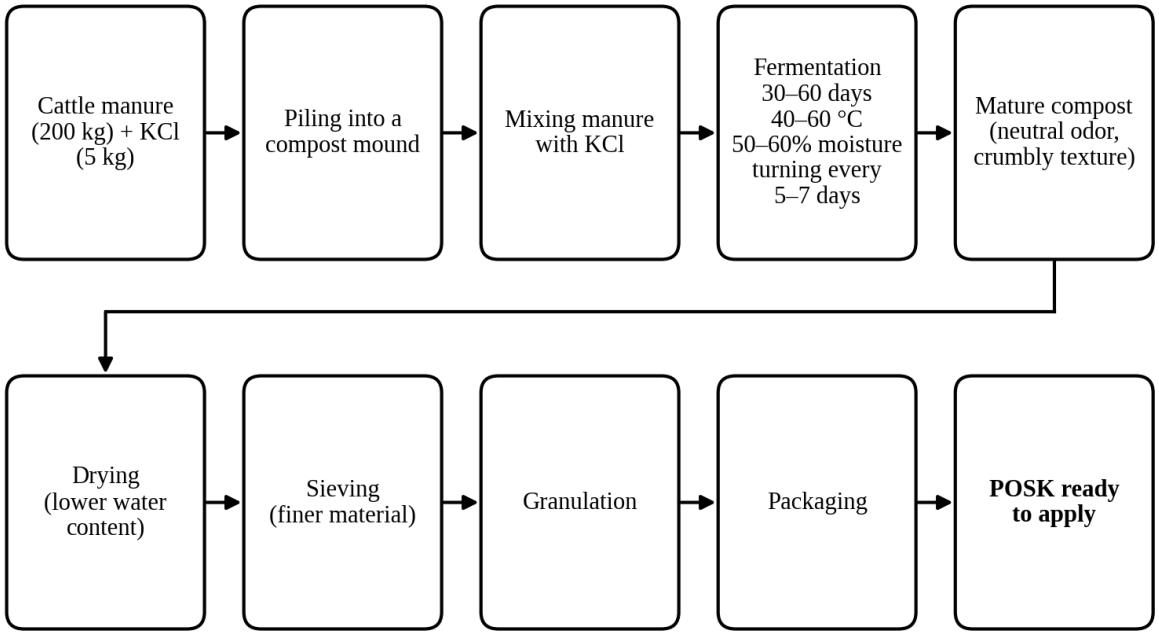



**Figure 1. Flow of POSK (Potassium-Enriched Cattle Manure Fertilizer) Production from Cattle Manure and KCl**

**Soil and POSK analysis**

Soil was analyzed at the start of the experiment, before the treatments were applied, and at the end of the experiment, and POSK was analyzed before application. The analyses were carried out at the Soil Laboratory of BSIP, Medan, following its laboratory work instructions (IK). Organic carbon was determined by spectrophotometry in soil (IK 0.1.5.0) and by gravimetry in POSK (IK 0.3.13.0); total nitrogen by the Kjeldahl method (IK 0.1.6.0 for soil and IK 0.3.14.0 for POSK); available phosphorus in soil by the Bray I method with spectrophotometry (IK 0.1.7.0); exchangeable potassium in soil by atomic absorption spectrometry (AAS; IK 0.1.8.0); and total $P_2O_5$ (spectrophotometry, IK 0.3.15.0) and $K_2O$ (AAS, IK 0.3.16.0) in POSK. The C/N ratio was calculated from organic carbon and total nitrogen.

**Observations and data analysis**

Plant height (from the stem base to the tip of the tallest leaf), stem diameter (measured with a caliper on both sides of the stem base), and the number of fully opened leaves were recorded on the five sample plants per plot weekly from 2 to 6 weeks after planting (WAP), giving five observations. At harvest, ear weight with husk was determined by weighing all unhusked ears in each plot. Ear weight without husk was determined by weighing the ears after removing the husk, leaving three husk leaves, for the whole plot and for the five sample plants. Sugar content was measured as % Brix with a hand refractometer. The instrument was calibrated to 0% with distilled water, fresh kernels were crushed, and one or two drops of the extract were placed on the prism. Data were analyzed by analysis of variance at the 5% level, and treatment means were compared with the least significant difference (LSD) test at 5%. The coefficient of variation (CV) of each variable was calculated as the square root of the error mean square divided by the grand mean.

The variables were chosen to represent vegetative growth, yield, and quality. Plant height, stem diameter, and leaf number describe vegetative growth and the photosynthetic capacity of the plant, and weekly records show how growth developed under each treatment. Ear weight with husk is the fresh

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weight at harvest, and ear weight without husk is the edible portion. Both were measured on two bases: per plot (all 30 plants), which expresses yield per unit area and is used for yield comparison, and per sample plant (five plants), which shows the response of an individual plant and allows the plot-level result to be checked at the plant level. Sugar content (% Brix) is the main quality attribute of sweet corn and responds directly to potassium supply, which was the reason for enriching the manure with KCl.

## Results and Discussion

### Results

Analysis of variance showed that POSK significantly affected all observed variables. NPK fertilizer significantly affected ear weight per plot (with and without husk) and sugar content, but not vegetative growth or ear weight per sample plant. The POSK × NPK interaction was significant for ear weight per plot and sugar content only (Table 2).

**Table 2. Summary of Analysis of Variance (F-Value, With P-Value In Parentheses) For the Effects of POSK, NPK Fertilizer, and Their Interaction**

| Variable | POSK (K) | NPK (N) | K × N |
|---|---|---|---|
| Plant height | 5.39 (0.004)* | 0.45 (0.719) ns | 0.29 (0.972) ns |
| Stem diameter | 3.32 (0.033)* | 1.06 (0.381) ns | 0.37 (0.940) ns |
| Number of leaves | 5.77 (0.003)* | 0.36 (0.782) ns | 0.60 (0.787) ns |
| Ear weight with husk per plot | 163.62 (<0.001)* | 79.00 (<0.001)* | 18.76 (<0.001)* |
| Ear weight without husk per plot | 155.14 (<0.001)* | 73.80 (<0.001)* | 17.15 (<0.001)* |
| Ear weight without husk per sample plant | 5.63 (0.003)* | 0.44 (0.726) ns | 0.28 (0.975) ns |
| Sugar content (% Brix) | 176.91 (<0.001)* | 28.36 (<0.001)* | 11.93 (<0.001)* |

** = significant at the 5% level; ns = not significant. Degrees of freedom were 3 and 30 for POSK and NPK and 9 and 30 for K × N. Plant height, stem diameter, and leaf number are for 6 weeks after planting. POSK = potassium-enriched cattle manure fertilizer. Coefficients of variation (%): plant height 14.2, stem diameter 13.9, number of leaves 7.9, ear weight with husk per plot 5.5, ear weight without husk per plot 5.8, ear weight without husk per sample plant 14.3, and sugar content 4.9.*

#### *Vegetative growth*

POSK significantly increased plant height from 3 to 6 WAP and stem diameter and leaf number from 2 to 6 WAP, whereas NPK fertilizer and the interaction had no significant effect at any age (Table 3). Plant height increased with the POSK dose at every observation (Figure 2). At 3 WAP, plants at K3 (54.7 cm) were significantly taller than those at K0 (41.6 cm) but not those at K2 (51.1 cm). At 4 WAP, K3 (102.5 cm) was significantly taller than K0 (80.3 cm) and K1 (93.3 cm) but not K2 (96.2 cm). At 6 WAP, K3 plants reached 185.9 cm, which was 24.7% taller than the control (149.1 cm).

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**Table 3. Plant Height, Stem Diameter, and Leaf Number of Sweet Corn At 6 Weeks After Planting as Affected by Posk and Npk Fertilizer**

| Treatment | Plant height (cm) | Stem diameter (mm) | Number of leaves |
|---|---|---|---|
| **POSK dose** | | | |
| K0 (0 t/ha) | 149.1 | 7.6 | 10.1 |
| K1 (15 t/ha) | 180.7 | 8.7 | 11.1 |
| K2 (25 t/ha) | 177.9 | 8.7 | 10.8 |
| K3 (30 t/ha) | 185.9 | 9.0 | 11.5 |
| **NPK fertilizer dose** | | | |
| N0 (0 kg/ha) | 169.8 | 8.4 | 10.8 |
| N1 (250 kg/ha) | 169.1 | 8.1 | 11.0 |
| N2 (300 kg/ha) | 179.2 | 8.9 | 11.0 |
| N3 (350 kg/ha) | 175.3 | 8.7 | 10.7 |

POSK had a significant effect (5% level) on all three variables; NPK fertilizer and the K × N interaction had no significant effect.

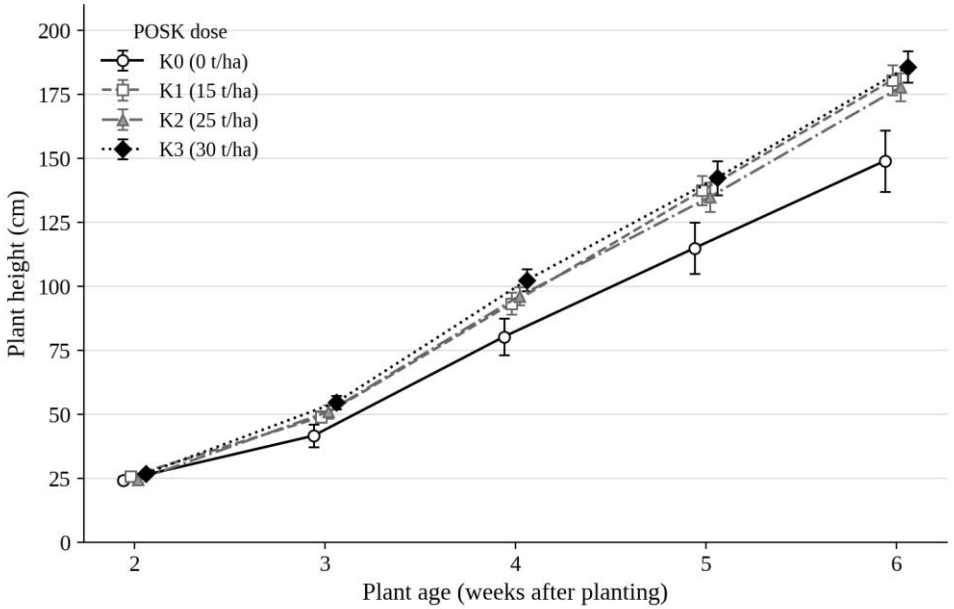



**Figure 2. Plant Height of Sweet Corn At 2–6 Weeks After Planting Under Four POSK Doses (K0–K3). Symbols Are Means and Bars Are ± Standard Error (N = 12 Plots Per POSK Dose)**

Stem diameter and leaf number followed the same trend. At 6 WAP, K3 produced a stem diameter of 9.0 mm and 11.5 leaves, compared with 7.6 mm and 10.1 leaves in the control. Plants at N2 tended to be taller (179.2 cm at 6 WAP) than those at N0 (169.8 cm), but the difference was not significant.

***Ear weight***

Ear weight with husk per plot was significantly affected by POSK, NPK fertilizer, and their interaction (Table 4, Figure 3). The mean ear weight increased from 3.8 kg per plot in the control to 6.2 kg at K3, an increase of 63%. K3 differed significantly from K0 and K2 but not from K1 (5.0 kg). Among NPK levels, N3 produced the highest ear weight (5.7 kg), 33% higher than N0 (4.3 kg).

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**Table 4. Ear Weight With Husk (Kg Per Plot) as Affected by POSK and NPK Fertilizer**

| POSK dose | N0 (0) | N1 (250) | N2 (300) | N3 (350) | Mean K |
|---|---|---|---|---|---|
| K0 (0 t/ha) | 2.4 b | 3.0 b | 4.8 b | 5.0 ab | 3.8 b |
| K1 (15 t/ha) | 4.2 ab | 4.4 ab | 5.7 ab | 5.7 ab | 5.0 ab |
| K2 (25 t/ha) | 4.3 ab | 3.8 b | 4.7 b | 6.1 a | 4.7 b |
| K3 (30 t/ha) | 6.3 a | 6.3 a | 6.0 a | 6.2 a | 6.2 a |
| Mean N | 4.3 ab | 4.4 ab | 5.3 a | 5.7 a | |

N0–N3 = NPK fertilizer at 0, 250, 300, and 350 kg/ha. Means followed by different letters in the same column differ significantly according to the LSD test at 5%.

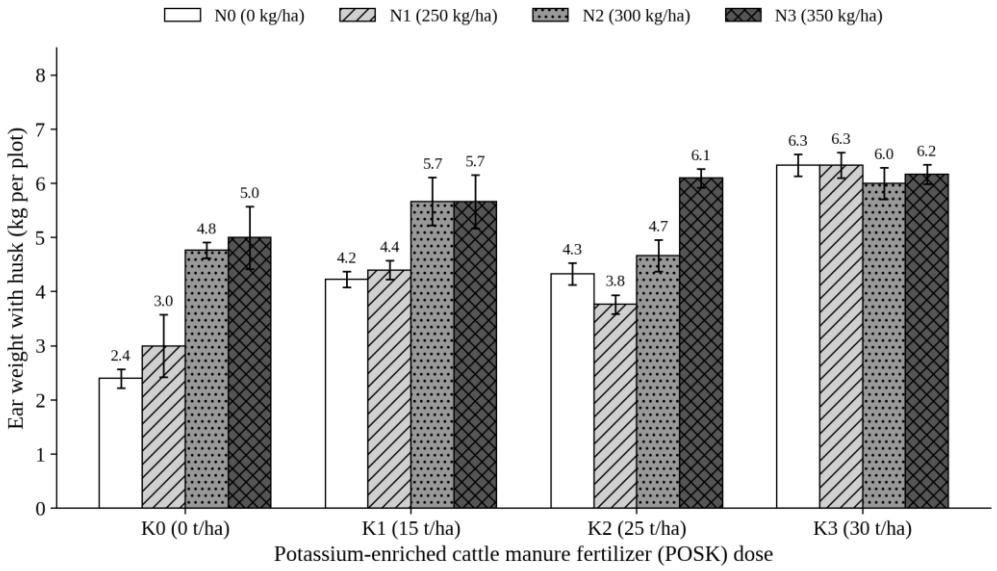



**Figure 3. Ear Weight With Husk Per Plot Under Combinations of POSK Doses (K0–K3) And NPK Fertilizer Doses (N0–N3). Bars Are Means and Error Bars Are ± Standard Error of The Three Blocks**

The significant interaction shows that the response to NPK fertilizer depended on the POSK dose. Without POSK (K0), ear weight rose from 2.4 kg at N0 to 5.0 kg at N3. At the highest POSK dose (K3), however, ear weight was 6.0–6.3 kg regardless of the NPK dose, and all K3 combinations shared the same letter. The lowest ear weight occurred at K0N0 (2.4 kg), and the highest at K3N0 and K3N1 (6.3 kg).

Ear weight without husk per plot showed the same pattern (Table 5). POSK increased it from 3.4 kg (K0) to 5.6 kg (K3), a gain of 65%, and NPK fertilizer increased it from 3.8 kg (N0) to 5.1 kg (N3), which differed significantly from N0 and N1. The K3 combinations produced 5.5–5.7 kg at every NPK level, whereas K0N0 produced the lowest value (2.0 kg). For ear weight without husk per sample plant, only POSK had a significant effect: the mean rose from 134.4 g at K0 to 161.5–168.4 g at K1–K3, and these three doses did not differ from each other. The much smaller F-values for ear weight per sample plant than for ear weight per plot (Table 2) show that means of five plants are noisier than plot totals, which include all 30 plants. This is the likely reason why the NPK and interaction effects found on the plot basis were not detected on the plant basis, and it is why plot values are used for yield comparisons while per-plant values show the plant-level response to POSK.

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**Table 5. Ear Weight Without Husk (Kg Per Plot) as Affected by POSK and NPK Fertilizer**

| POSK dose | N0 (0) | N1 (250) | N2 (300) | N3 (350) | Mean K |
|---|---|---|---|---|---|
| K0 (0 t/ha) | 2.0 b | 2.6 b | 4.3 ab | 4.5 ab | 3.4 b |
| K1 (15 t/ha) | 3.7 ab | 3.9 ab | 4.9 ab | 5.1 a | 4.4 ab |
| K2 (25 t/ha) | 3.9 ab | 3.3 ab | 4.3 ab | 5.4 a | 4.2 ab |
| K3 (30 t/ha) | 5.6 a | 5.7 a | 5.5 a | 5.5 a | 5.6 a |
| Mean N | 3.8 b | 3.9 b | 4.7 ab | 5.1 a | |

N0–N3 = NPK fertilizer at 0, 250, 300, and 350 kg/ha. Means followed by different letters in the same column differ significantly according to the LSD test at 5%.

***Sugar content***

Sugar content was significantly affected by POSK, NPK fertilizer, and their interaction (Table 6, Figure 4). The mean sugar content increased from 10.0% at K0 to 16.1% at K3 and from 12.8% at N0 to 15.0% at N3. All K3 combinations gave 16.0–16.3% Brix, whereas K0N0 and K0N1 gave only 7.3% and 7.7%. At the same NPK dose of 250 kg/ha (N1), 30 t/ha of POSK (K3N1) increased ear weight without husk from 2.6 to 5.7 kg per plot, an increase of 119.2%, and sugar content from 7.7% to 16.3%, an increase of 111.7%.

**Table 6. Sugar Content (% Brix) Of Sweet Corn as Affected by POSK and NPK Fertilizer**

| POSK dose | N0 (0) | N1 (250) | N2 (300) | N3 (350) | Mean K |
|---|---|---|---|---|---|
| K0 (0 t/ha) | 7.3 b | 7.7 b | 11.7 b | 13.3 b | 10.0 b |
| K1 (15 t/ha) | 14.0 ab | 14.0 ab | 14.7 ab | 15.0 ab | 14.4 ab |
| K2 (25 t/ha) | 14.0 ab | 13.7 ab | 14.3 ab | 15.7 ab | 14.4 ab |
| K3 (30 t/ha) | 16.0 a | 16.3 a | 16.0 a | 16.0 a | 16.1 a |
| Mean N | 12.8 b | 12.9 b | 14.2 ab | 15.0 a | |

N0–N3 = NPK fertilizer at 0, 250, 300, and 350 kg/ha. Means followed by different letters in the same column differ significantly according to the LSD test at 5%.

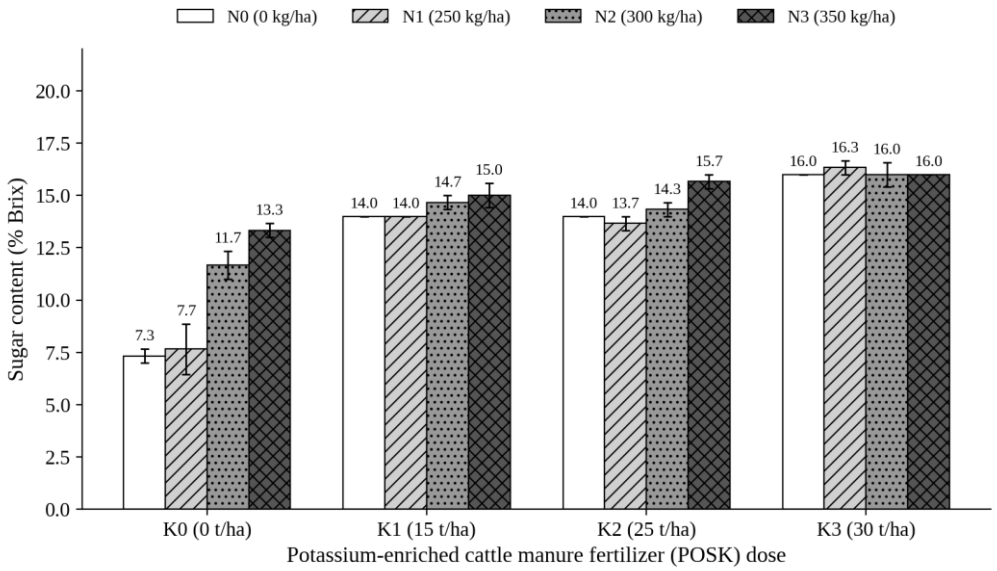



**Figure 4. Sugar Content (% Brix) Of Sweet Corn Under Combinations of POSK Doses (K0–K3) and NPK Fertilizer Doses (N0–N3). Bars Are Means and Error Bars Are ± Standard Error of the Three Blocks**

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***Properties of POSK and soil***

POSK contained 23.80% organic carbon, 2.53% total nitrogen, 0.63% $P_2O_5$, and 9.09% $K_2O$, with a C/N ratio of 9.40 (Table 7). Its potassium content was about 3.6 times its nitrogen content and about 14 times its phosphorus content, which reflects the KCl added during processing. Between the start and the end of the experiment, soil organic carbon rose from 1.22% to 1.76% (+44%), total nitrogen from 0.12% to 0.16% (+33%), Bray I phosphorus from 24.84 to 27.84 ppm (+12%), and exchangeable potassium from 0.65 to 1.38 me/100 g (+112%), while the C/N ratio changed from 10.7 to 11.0 (Table 8).

**Table 7. Chemical Properties of POSK Used in the Experiment**

| Parameter | Value | Method |
|---|---|---|
| Organic carbon (%) | 23.80 | IK 0.3.13.0 (gravimetry) |
| Total nitrogen (%) | 2.53 | IK 0.3.14.0 (Kjeldahl) |
| $P_2O_5$ (%) | 0.63 | IK 0.3.15.0 (spectrophotometry) |
| $K_2O$ (%) | 9.09 | IK 0.3.16.0 (AAS) |
| C/N ratio | 9.40 | Calculated |

**Table 8. Soil Chemical Properties at the Start and End of the Experiment**

| Parameter | Start | End | Method |
|---|---|---|---|
| Organic carbon (%) | 1.22 | 1.76 | IK 0.1.5.0 (spectrophotometry) |
| Total nitrogen (%) | 0.12 | 0.16 | IK 0.1.6.0 (Kjeldahl) |
| Bray I phosphorus (ppm P) | 24.84 | 27.84 | IK 0.1.7.0 (spectrophotometry) |
| Exchangeable K (me/100 g) | 0.65 | 1.38 | IK 0.1.8.0 (AAS) |
| C/N ratio | 10.7 | 11.0 | Calculated from organic C and total N |

*IK = laboratory work instruction; AAS = atomic absorption spectrometry. Soil values are single values for the start and end of the experiment, not values by treatment.*

**Discussion**

The mechanisms proposed in this section are inferred from the literature and from the limited chemical analyses in Tables 7 and 8. Soil properties were measured only once at the start and once at the end of the experiment and not by treatment, and nutrient release from POSK and nutrient uptake by the plants were not measured, so the explanations are hypotheses for future testing and not conclusions of this study.

The positive effect of POSK on growth is consistent with the role of organic matter in improving soil physical, chemical, and biological properties, which makes nutrient uptake by roots more efficient. Organic matter can also stimulate soil microbial activity and thereby the mineralization of nitrogen, phosphorus, and potassium. Nitrogen supports chlorophyll and protein formation and therefore photosynthesis and vegetative growth, while potassium contributes to cell division and elongation. Organic fertilizers made from livestock waste have been shown to improve growth by increasing nutrient availability and soil structure (Abidin 2023), and organic fertilizer raised the height of sweet corn by improving rooting conditions and nutrient uptake efficiency (Aminah 2022) .

NPK fertilizer did not significantly affect vegetative growth, although plants at N2 tended to be taller. The nutrients released from POSK probably met much of the vegetative demand, so additional NPK gave little response. The absence of an interaction for the growth variables suggests that the two fertilizers acted independently on vegetative growth, which can happen when the nutrient supply from each source is already sufficient.

The significant POSK × NPK interaction for ear weight indicates that the response to NPK depended on

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the POSK dose. On the control soil, increasing the NPK dose raised ear weight from 2.4 to 5.0 kg per plot, whereas at 30 t/ha of POSK ear weight was already at its maximum without NPK. POSK may have improved the water-holding capacity, aeration, and cation exchange capacity of the Ultisol, supplied nutrients gradually, and improved the efficiency of nutrient uptake, while its potassium may have supported the translocation of photosynthates to the ear. NPK fertilizer, in contrast, supplies nutrients quickly and is most useful when the soil supplies little, as in the control. Similar benefits of combining cattle manure and NPK fertilizer on sweet corn ear weight have been reported (Asbur et al. 2015; Syahputra 2024).

The analysis of POSK (Table 7) gives a measured basis for this interpretation. If its nutrient contents apply to the material as applied, 30 t/ha of POSK carried about 759 kg N, 189 kg $P_2O_5$, and 2,727 kg $K_2O$ per hectare in total, which is roughly 17, 4, and 61 times the 45 kg of each nutrient supplied by NPK at 300 kg/ha. These are total contents and not plant-available amounts, but the large difference helps to explain why additional NPK gave no further response at K3, and the very high potassium supply is consistent with the high and uniform sugar content at K3 (16.0–16.3% Brix). The same amount of potassium may also exceed crop demand, which is a further reason to test lower POSK doses and to evaluate cost. The soil analysis (Table 8) shows higher organic carbon, total nitrogen, available phosphorus, and exchangeable potassium at the end than at the start of the experiment, in line with the organic matter and nutrient inputs, but because the soil values are not given by treatment, the changes cannot be attributed to individual POSK or NPK doses.

Sugar content responded in the same way. Potassium activates enzymes involved in sugar and starch synthesis and moves photosynthates from the leaves to the kernels, which may explain the higher sugar content with POSK and with NPK fertilizer (Arsyad et al. 2025; Paskalis 2024). (Mustaqim 2024) likewise found that potassium fertilizer improved the sweetness of sweet corn. In our experiment, sugar content at K3 (16.0–16.3% Brix) was reached with or without NPK fertilizer, which suggests that the potassium supplied by POSK was sufficient for sugar accumulation, although soil and plant potassium were not measured to confirm this.

At the same NPK dose of 250 kg/ha, ear weight without husk and sugar content were 119.2% and 111.7% higher with 30 t/ha of POSK than without POSK, which indicates that POSK can compensate for a lack of NPK under the conditions of this experiment. To express this as fertilizer-use efficiency, we calculated the agronomic efficiency of NPK (AE, the increase in ear weight without husk per kilogram of NPK applied, with plot yield converted to kg/ha using the 5.4 m² plot area). At the recommended dose of 300 kg/ha, AE was about 14 kg of ears per kg of NPK without POSK (K0) but about −1 kg per kg at 30 t/ha of POSK (K3), that is, no gain from the added NPK. Because ear weight and sugar content at K3N0 were statistically equal to those of K3 with NPK, POSK at 30 t/ha may partially or fully replace NPK fertilizer in this experiment. These results apply only to the soil, season, hybrid, and doses tested. A recommendation to substitute NPK would also require an economic analysis (the cost of producing, transporting, and applying 30 t/ha of POSK compared with NPK) and multi-location data, which this study did not include.

This study has several limitations. It was conducted at one site in one growing season with a single hybrid variety, so results may differ under other soils, climates, and seasons. Only four doses of each fertilizer were tested, and the highest POSK dose gave the best result, so the optimum POSK dose could not be identified. POSK was analyzed once, and soil was analyzed only at the start and end of the experiment and not by treatment, so changes in soil properties cannot be attributed to individual treatments, and nutrient release and plant uptake were not measured. Economic feasibility was not evaluated, and 30 t/ha is a large quantity to transport and apply. Multi-location and multi-season trials with a wider dose range, soil and plant nutrient analyses by treatment, and a cost analysis are therefore

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needed.

## Conclusion

POSK significantly improved the growth, ear weight, and sugar content of sweet corn on Ultisol, and the best results were obtained at 30 t/ha, the highest dose tested. NPK fertilizer increased ear weight per plot and sugar content, but its effect depended on the POSK dose: it was large without POSK and absent at 30 t/ha of POSK. Under the conditions of this experiment, 30 t/ha of POSK without NPK gave ear weight and sugar content statistically equal to those of the best combinations, so POSK made from on-site cattle manure may partially replace NPK fertilizer in sweet corn on Ultisol. Further research is recommended to (1) test a wider range of POSK doses, including intermediate doses between 15 and 30 t/ha and doses above 30 t/ha, together with reduced NPK rates, to identify the optimum dose, because the highest dose tested gave the best result; (2) repeat the experiment at several locations and in several seasons and with other sweet corn varieties to verify that the results hold; (3) measure soil properties and plant nutrient uptake, including potassium, by treatment to confirm the mechanisms proposed here; and (4) analyze the cost and benefit of producing, transporting, and applying POSK compared with NPK fertilizer. These steps are needed before POSK can be recommended to farmers as a partial substitute for NPK fertilizer.

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