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Effects of manure and liquid organic fertilizer from onion peel waste on the growth and yield of sweet corn (Zea mays L. var. saccharata)

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ABSTRACT

Sweet corn is a high-value horticultural crop that responds strongly to organic nutrient management. This study evaluated the effects of manure type, the concentration of liquid organic fertilizer from onion peel waste (POC), and their interaction on sweet corn grown in Inceptisol field soil at Kwala Bekala, Medan Johor, North Sumatra. The experiment was conducted from March to June 2026 using a factorial randomized block design with three replications. The first factor was manure type: no manure (K0), chicken manure 2 kg/plot (K1), cattle manure 2 kg/plot (K2), and goat manure 2 kg/plot (K3). The second factor was onion peel POC concentration: no POC (P0), 250 ml/L (P1), and 500 ml/L (P2). The observed variables were plant height, stem diameter, cob length, cob diameter, and yield weight per plant. Manure significantly affected plant height and had a highly significant effect on stem diameter, cob diameter, and yield weight. Onion peel POC had a highly significant effect on stem diameter, cob diameter, and yield weight. The interaction significantly affected plant height, stem diameter, and cob diameter and had a highly significant effect on yield weight. K2P2 produced the tallest plants, largest stem diameter, and largest cob diameter, whereas K3P1 produced the highest yield weight (261.00 g/plant), a 72.85% increase over the untreated control (K0P0, 151.00 g/plant). Thus, 2 kg/plot of goat manure combined with 250 ml/L of onion peel POC is recommended to improve sweet corn yield.

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1. INTRODUCTION

Corn (Zea mays L.) is one of the world’s major cereal crops after rice and wheat. In Indonesia, corn is important as a food source, animal feed, and industrial raw material. According to data from the Central Statistics Agency (BPS, 2025), the production of dried shelled corn with a moisture content of 14% reached 15.14 million metric tons in 2024. One type of corn with high market demand is sweet corn (Zea mays saccharata Sturt), which is favored for its sweet taste, softer kernel texture, and suitability for fresh consumption.

Efforts to increase sweet corn productivity still face challenges related to soil fertility and fertilizer efficiency. Recent studies on sweet corn indicate that productivity can be hampered by limitations in soil fertility, particularly low nutrient and organic matter availability; therefore, fertilizer management must be directed not only toward supplying N, P, and K but also toward improving soil chemical properties (Gumilang et al., 2025). This issue is relevant to the Kwala Bekala region because previous soil studies have reported Inceptisol characteristics at this location, while experimental plots with low or variable levels of organic matter generally require additional organic matter to maintain nutrient cycling and crop performance (Matondang et al., 2014; Sihite et al., 2016). In the context of sustainable agriculture, organic fertilizers and soil conditioners made from local waste are becoming increasingly important because they support biomass recycling, improve soil quality, and reduce dependence on synthetic inputs.

Manure is an organic input that serves as a source of macro- and micronutrients as well as a soil conditioner. The application of organic amendments can increase soil organic matter, microbial activity, and nutrient availability, although its effectiveness depends heavily on the type of material, maturity, application rate, and soil conditions (Xu et al., 2025). In corn, the application of cow manure compost has been reported to promote growth and improve soil quality by increasing organic matter and nutrient availability (Li et al., 2022). Another study on sweet corn also showed that cow manure increased plant height, the number of leaves, and leaf area, thereby contributing to the plants' vegetative vigor (Mukhlis et al., 2024). In this study, the same rate of 2 kg/plot was used for chicken, cattle, and goat manure so that the effects of manure type could be compared under a uniform plot-scale basal organic amendment.

In addition to manure, the use of onion peel waste as a raw material for liquid organic fertilizer (POC) has both ecological and agronomic relevance. Onion peels contain phenolic compounds and flavonoids such as quercetin, making them a valuable waste material for development into agricultural products and biostimulants (Celano et al., 2021). Research by Zhang et al.(2024) shows that onion peel waste concentrate can enhance the growth of several vegetable crops through both foliar application and sub-irrigation, thereby reinforcing the argument that onion peel waste not only serves as a nutrient source but also has potential as a biostimulant input.

In the form of POC, the fermentation process using bioactivators such as EM4 can help convert organic matter into a solution that is easier to apply and potentially contains macro- and micronutrients. Ernis et al. (2023) reported that the production of onion peel POC using various concentrations of EM4 over 14 days resulted in physicochemical changes that served as indicators of the fermentation process. In sweet corn, liquid organic fertilizers derived from plant extracts have been reported to enhance growth, yield, quality, and nutrient uptake, but their effectiveness depends on the concentration or application rate (Pangaribuan et al., 2019).

Although research on manure and onion peel liquid fertilizer (POC) for sweet corn has expanded, studies specifically comparing three types of manure while combining them with onion peel POC remain limited. This research gap is significant because each type of manure has different nutrient release characteristics, whereas onion peel POC can provide soluble nutrients and bioactive compounds resulting from fermentation. Therefore, this study aims to analyze the effects of chicken, cattle, and goat manure, onion peel POC concentration, and their interactions on the growth and yield of sweet corn.

2. METHOD

2.1 Research Location and Time

This study was conducted at the Faculty of Agriculture's Experimental Farm, Universitas Al Azhar Medan, Gang Ternak Kwala Bekala, Medan Johor District, North Sumatra Province, from March to June 2026. The experimental field was described as an Inceptisol field soil based on previous soil studies conducted in the Kwala Bekala area. Baseline soil chemical characteristics, including soil pH, organic C, total N, available P, and exchangeable K, were not analyzed in the present study; therefore, the interpretation of treatment effects is limited to crop growth and yield responses and should be supported by soil testing in future research.

2.2 Research Materials and Tools

The materials used in this study were Bonanza new F1 Hybrid Sweet Corn Seeds, cattle manure, goat manure, chicken manure, liquid organic fertilizer (POC), and a mixture of rice washing water and onion skins. The tools used in this study were a hoe, a vernier caliper, rope, a scale, a knife, a bucket, a measuring tape, writing utensils, documentation tools, a watering can, bottles or containers, a spray bottle, stakes, shade netting, and plot markers.

2.3. POC Development Process

Onion peel POC was prepared through 14 days of anaerobic fermentation. The ingredients consisted of rice washing water as a source of carbohydrates and micronutrients for decomposer microorganisms, red onion peel and garlic peel as sources of potassium, phosphorus, and natural growth-supporting compounds, EM4 as a bioactivator, and molasses or sugar as a microbial energy source. The onion peels were cleaned and cut into smaller pieces to increase the surface area for decomposition. EM4 and molasses were dissolved and allowed to stand for approximately 15 minutes before mixing. The materials were placed in plastic bottles or jerrycans, sealed under anaerobic conditions with approximately 20% headspace, and stored in a shaded area. Gas was released every 24 hours to prevent excessive pressure. Successful fermentation was indicated by a fresh, acidic aroma similar to fermented tape, a darker, brownish color, and reduced gas production from days 10-14.

2.4. Research Methods

This study used a factorial randomized block design (RBD) with two factors and three replications. The first factor was the type of manure (K), consisting of K0 = no manure, K1 = 2 kg/plot of chicken manure, K2 = 2 kg/plot of cattle manure, and K3 = 2 kg/plot of goat manure. The second factor was the concentration of onion peel POC (P), with P0 = no POC, P1 = 250 ml/L, and P2 = 500 ml/L. Thus, there were 12 treatment combinations and 36 experimental units. This design was chosen to reflect a practical, farmer-oriented application rate and to allow comparison under the same quantity of basal organic material. However, because chicken, cattle, and goat manure differ in nutrient concentrations, organic matter content, moisture, maturity, and nutrient-release patterns, this fixed-rate design does not constitute an isonutrient comparison. The interpretation of manure effects is therefore limited to crop responses to each manure source at the same plot rate. Organic amendment studies emphasize that crop response depends on amendment type, application rate, decomposition stage, and soil condition; consequently, future studies should standardize manure treatments based on N equivalence, organic matter input, or C/N ratio (Diacono & Montemurro, 2010; Xu et al., 2025).

Each plot measured 100 cm × 100 cm, with 50 cm between plots and 100 cm between replicates. The planting spacing used was 70 cm × 20 cm. Each plot contained 10 plants, with three sample plants per plot, resulting in 360 total plants and 108 sample plants. Manure was applied two weeks before planting by spreading it evenly during land preparation, in accordance with the assigned treatment. The rate was presented in kg/plot because the experiment was arranged and analyzed at plot scale.

2.5. Research Implementation and Crop Maintenance

Land preparation involved manually removing weeds and loosening the soil until it became crumbly. Plots were arranged in three replicates, with 12 plots in each replicate. Sweet corn seeds were planted at a depth of about 1 cm. One week after planting, thinning was performed by removing weaker plants and retaining one healthy plant at each planting site. Liquid organic fertilizer from onion peel waste was applied as a root-zone drench, not as a foliar spray, once every week from 2 to 7 weeks after planting (six applications). For P1 and P2, POC was diluted at 250 mL/L and 500 mL/L, respectively, and approximately 100 mL of prepared solution was applied per plant per application around the root zone under the leaf canopy in the morning. Plants in P0 received the same volume of water to maintain comparable application volume. Crop maintenance includes watering twice daily in the morning and evening or as needed based on field conditions until field capacity is reached, weekly manual weeding, replanting missing plants one week after planting using seedlings of the same age, and pest control as needed using botanical insecticides such as neem or lemongrass. Harvesting is carried out when the corn silk has dried and turned brown to black and when the ears have reached the stage suitable for fresh consumption of sweet corn.

2.6. Data Analysis

Data analysis was performed using analysis of variance (ANOVA) based on a factorial RBD model. The mathematical model used was:

$$Yijk = \mu + \rho i + Nj + Pk + (NP)jk + \varepsilon ijk \quad (1)$$

where Yijk = observed value, μ = overall mean, ρi = effect of the i-th replication/block, Kj = effect of the j-th level of manure, Pk = effect of the k-th level of liquid organic fertilizer from onion peel waste, (KP)jk = interaction effect between manure and liquid organic fertilizer from onion peel waste, and εijk = experimental error.

If the analysis of variance indicates a significant effect, the analysis continues with Duncan’s Multiple Range Test (DMRT) at the 5% significance level, as required for interpretation.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The application of manure and the interaction between manure and onion peel POC had a significant effect on plant height at 6 weeks after planting (6 WAP), whereas the POC treatment alone had no significant effect. The mean plant heights are presented in Table 1.

Table 1. Average plant height of sweet corn at 6 WAP based on manure type and onion peel POC concentration

Treatment	P0	P1	P2	Average
K0	75,67 d	109,00 abc	94,33 abc	93,00 c
K1	109,33 abc	99,67 bc	118,33 ab	109,11 ab
K2	110,33 abc	99,00 bc	124,00 a	111,11 a
K3	100,67 abc	110,33 abc	110,33 abc	107,11 abc
Average	99,00	104,50	111,75	

Note: K0 = no manure; K1 = 2 kg of chicken manure per plot; K2 = 2 kg of cattle manure per plot; K3 = 2 kg of goat manure per plot; P0 = no POC; P1 = 250 ml/L; P2 = 500 ml/L. Numbers followed by different letters in the same row or column indicate significant differences according to Duncan's test. Lowercase letters indicate the 5% level, while uppercase letters indicate the 1% level.

Table 1 shows that cattle manure (K2) produced the highest average plant height, at 111.11 cm, followed by chicken manure (K1) at 109.11 cm and goat manure (K3) at 107.11 cm. Plants without manure (K0) showed the lowest average height, at 93.00 cm. In combination, the K2P2 treatment produced the tallest plant height, at 124.00 cm. This pattern indicates that the application of cattle manure combined with 500 ml/L onion peel POC is capable of creating a root environment that better supports vegetative growth. Cattle manure tends to release nutrients gradually and improve soil structure, while POC can provide soluble nutrients and fermentation metabolites that are more readily available to plants.

These results are consistent with those of Hua et al. (2020), who showed that long-term application of manure can improve nitrogen use efficiency by increasing soil organic matter and soil fertility. Shah et al. (2023) reported that organic fertilizer sources can improve soil physical properties, nutrient uptake, growth, and corn yield. Thus, the increase in plant height in the K2P2 treatment can be interpreted as the result of an interaction between the improvement in soil physical and chemical conditions by cattle manure and the addition of readily available nutrients and fermentation-derived compounds from onion peel POC. However, the lack of a significant effect from onion peel POC alone indicates that soluble organic inputs may not be strong enough to promote plant height without simultaneous improvement of the root-zone environment by manure.

3.2 Stem Diameter

Manure and onion peel POC had a very significant effect on stem diameter at 6 weeks after planting, while their interaction had a significant effect. The mean stem diameters are presented in Table 2.

Table 2. Mean diameter of sweet corn stalks at 6 MST as a function of manure type and onion peel POC concentration

Treatment	P0	P1	P2	Average
K0	13,43 c	14,40 bc	13,83 c	13,89 cC
K1	13,73 c	14,63 b	17,13 a	15,16 bB
K2	16,03 ab	14,20 c	17,57 a	15,93 aA
K3	14,93 b	16,43 a	16,83 a	16,06 aA
Average	14,53 cC	14,92 bB	16,34 aA	

Note: K0 = no manure; K1 = 2 kg of chicken manure per plot; K2 = 2 kg of cattle manure per plot; K3 = 2 kg of goat manure per plot; P0 = no POC; P1 = 250 ml/L; P2 = 500 ml/L. Numbers followed by different letters in the same row or column indicate significant differences according to Duncan's test. Lowercase letters indicate the 5% level, while uppercase letters indicate the 1% level.

Table 2 shows that the largest stem diameter for the manure treatment was observed in K3 (16.06 mm), followed by K2 (15.93 mm), while K0 produced the smallest diameter (13.89 mm). For the POC factor, P2 yielded the highest stem diameter (16.34 mm), higher than P1 (14.92 mm) and P0 (14.53 mm). The K2P2 combination produced the highest stem diameter, at 17.57 mm. Stem diameter is an indicator of plant strength and the plant's capacity to support cob formation. An increase in stem diameter indicates that organic treatments not only stimulate plant elongation but also strengthen the formation of vegetative tissue.

The high stem diameter response in the K2P2 treatment is thought to be related to more balanced availability of N, P, and K in the root zone. Nitrogen supports chlorophyll formation and meristematic tissue growth; phosphorus contributes to root development and energy transfer; and potassium regulates osmotic balance, enzyme activity, and the translocation of photosynthates.

Hussain et al. (2015) confirmed that potassium plays a crucial role in enhancing growth, physiology, nutrient uptake, and the quality of corn yields. Thenveettil et al. (2024) also explain that adequate potassium is important for the physiology and growth of corn. In this study, a concentration of 500 ml/L was more effective for stem diameter, although it was not necessarily the most favorable concentration for final yield weight.

3.3 Cob Length

Manure, onion peel POC, and the interaction between the two had no significant effect on cob length. The mean cob lengths are presented in Table 3.

Table 3. Average length of sweet corn cobs as a function of manure type and POC concentration from onion skins

Treatment	P0	P1	P2	Average
K0	23,13	21,83	22,67	22,54
K1	23,50	21,93	22,20	22,54
K2	24,20	20,93	25,43	23,52
K3	22,80	23,50	23,50	23,27
Average	23,41	22,05	23,45	

Note: K0 = no manure; K1 = 2 kg of chicken manure per plot; K2 = 2 kg of cattle manure per plot; K3 = 2 kg of goat manure per plot; P0 = no POC; P1 = 250 ml/L; P2 = 500 ml/L. Numbers followed by different letters in the same row or column indicate significant differences according to Duncan's test. Lowercase letters indicate the 5% level, while uppercase letters indicate the 1% level.

Table 3 shows that the differences in treatments did not result in significant differences in cob length. Numerically, treatment K2 yielded the highest mean for the manure factor (23.52 cm), P2 yielded the highest mean for the POC factor (23.45 cm), and the K2P2 combination resulted in the longest cob length (25.43 cm). However, since these differences were not significant, the numerical increases cannot yet serve as the basis for a single recommendation. This indicates that cob length is relatively more stable than cob diameter and yield in response to variations in organic treatments.

The lack of a significant effect on cob length may be due to the dominance of genetic factors in the Bonanza F1 variety, uniformity of the harvest phase, and pollination conditions. Cob length is generally determined earlier during ear initiation and elongation, whereas fertilization more often influences kernel filling, cob diameter, and cob weight during the generative phase. Therefore, the organic treatments in this study were more responsive in parameters related to cob enlargement and biomass accumulation than in longitudinal cob growth. According to Diacono and Montemurro (2010), plant response to organic amendments is influenced by the type of material, application rate, timing of application, and soil conditions.

3.4 Cob Diameter

Manure and onion peel POC had a very significant effect on cob diameter, while the interaction between the two had a significant effect. The mean cob diameters are presented in Table 4.

Table 4. Mean diameter of sweet corn cobs as a function of manure type and onion peel POC concentration

Treatment	P0	P1	P2	Average
K0	48,77 d	49,77 cd	50,77 cd	49,77 cC
K1	49,23 cd	52,27 c	55,23 b	52,24 bB
K2	49,77 cd	54,23 b	58,77 a	54,26 aA
K3	50,23 cd	56,27 ab	56,83 a	54,44 aA
Average	49,50 cC	53,14 bB	55,40 aA	

Note: K0 = no manure; K1 = 2 kg of chicken manure per plot; K2 = 2 kg of cattle manure per plot; K3 = 2 kg of goat manure per plot; P0 = no POC; P1 = 250 ml/L; P2 = 500 ml/L. Numbers followed by different letters in the same row or column indicate significant differences according to Duncan's test. Lowercase letters indicate the 5% level, while uppercase letters indicate the 1% level.

Table 4 shows that goat manure (K3) produced the highest average cob diameter among the manure treatments, at 54.44 mm, not far from K2 at 54.26 mm. Among the POC treatments, P2 produced the highest cob diameter, at 55.40 mm. The K2P2 combination produced the largest cob diameter, at 58.77 mm. These results indicate that the combination of manure and onion peel POC can enhance cob enlargement, particularly when favorable soil conditions and soluble nutrients are available to support the generative phase.

Cob diameter is closely related to kernel formation and the translocation of photosynthates from leaves to reproductive organs. Potassium availability is crucial because this element plays a role in the transport of photosynthetic products, kernel filling, and corn yield quality. Sofyan and Sara (2018) reported that the application of organic and inorganic fertilizers affects the uptake of N, P, and K as well as sweet corn yield. These findings are also consistent with Zhang et al. (2024), who reported that onion peel waste concentrate has the potential to enhance vegetable plant growth, suggesting that the onion peel POC used in this study may function through a combination of nutrient supply and biostimulant effects.

3.5 Yield Weight per Plant (g/plant)

Manure, onion peel POC, and their interaction had a very significant effect on yield weight per plant. The average yield weight per plant is presented in Table 5.

Table 5. Average yield weight of sweet corn per plant (g/plant) based on manure type and onion peel POC concentration

Treatment	P0	P1	P2	Average
K0	151,00 jJ	150,67 jJ	150,67 jJ	150,78 dD
K1	181,00 hH	201,00 fF	172,33 iI	184,78 cC
K2	211,00 eE	191,00 gG	231,00 cC	211,00 bB
K3	241,00 bB	261,00 aA	221,00 dD	241,00 aA
Average	196,00 bB	200,92 aA	193,75 cC	

Note: K0 = no manure; K1 = 2 kg of chicken manure per plot; K2 = 2 kg of cattle manure per plot; K3 = 2 kg of goat manure per plot; P0 = no POC; P1 = 250 ml of POC per liter; P2 = 500 ml of POC per liter. Values are expressed as yield weight per plant (g/plant). Numbers followed by different letters in the same row or column indicate significant differences according to Duncan's test. Lowercase letters indicate the 5% level, while uppercase letters indicate the 1% level.

Table 5 shows that goat manure (K3) produced the highest average yield weight, at 241.00 g/plant, followed by K2 at 211.00 g/plant, K1 at 184.78 g/plant, and K0 at 150.78 g/plant. For the POC factor, P1 produced the highest average yield weight (200.92 g/plant), followed by P0 (196.00 g/plant) and P2 (193.75 g/plant), indicating that yield response did not increase linearly with higher POC concentration. At the combination level, the K3P1 treatment yielded the highest production weight, namely 261.00 g/plant, while the untreated control (K0P0) reached only 151.00 g/plant. Thus, K3P1 increased yield weight by 72.85% compared with K0P0, confirming that the integration of goat manure and moderate onion peel POC concentration was the most effective treatment for yield formation in this experiment.

The superiority of K3P1 suggests that goat manure may provide soil conditions and nutrient release patterns that are more suitable for cob filling, while a POC concentration of 250 ml/L appears sufficient to support production without causing possible nutrient or osmotic imbalance. This phenomenon is important because using POC at excessively high concentrations does not always increase yield; higher concentrations may alter the balance of available nutrients, microbial activity, or solution concentration around the root zone. Xu et al. (2025) also confirm that the benefits of organic amendments are influenced by the characteristics of the material, the application rate, and soil ecosystem conditions. Thus, the agronomic recommendation from this study is directed toward the K3P1 combination for production purposes, even though K2P2 produced better responses in several vegetative and cob diameter parameters.

4. CONCLUSION

The application of manure had a significant effect on plant height and a highly significant effect on stem diameter, cob diameter, and yield weight per plant, but had no significant effect on cob length. The application of onion peel POC had a highly significant effect on stem diameter, cob diameter, and yield weight per plant, but had no significant effect on plant height and cob length. The interaction between manure and onion peel POC had a significant effect on plant height, stem diameter, and cob diameter, as well as a highly significant effect on yield weight per plant. The K2P2 combination produced the highest plant height, stem diameter, and cob diameter, while the K3P1 combination produced the highest yield weight of 261.00 g/plant, representing a 72.85% increase compared with the untreated control. Based on the production parameter, the combination of 2 kg/plot of goat manure, equivalent to approximately 20 tonnes/ha, with 250 ml/L onion peel POC is recommended as the most promising treatment for sweet corn cultivation using local organic inputs. Further research is needed to confirm the sweet corn variety, analyze the chemical composition and C/N ratio of each manure source and onion peel POC, measure soil pH, organic C, total N, available P, and exchangeable K before and after treatment, and convert plot-level yield into tonnes/ha to make the recommendation more practical for farmers.

Practically, this finding indicates that goat manure and fermented onion peel waste can be used as locally available organic fertilizer resources to partially reduce dependence on synthetic fertilizers, recycle onion peel waste, and support sweet corn production on Inceptisol soils with low or variable organic matter. However, the recommendation should be interpreted with caution because manure nutrient contents, the chemical composition of liquid organic fertilizer from onion peel waste, and pre- and post-treatment soil chemical properties were not measured. Further research is needed to validate these responses across sweet corn varieties and growing seasons, analyze the chemical composition and C/N ratio of each manure source and liquid organic fertilizer from onion peel waste, measure soil pH, organic C, total N, available P, and exchangeable K before and after treatment, and convert plot-level yield into tonnes/ha to make the recommendation more practical for farmers.

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