



SOIL ORGANIC CARBON DYNAMICS, GROWTH, AND YIELD OF SWEET CORN UNDER DIFFERENT RATES OF TRICHODERMA-ENRICHED SUGARCANE FILTER CAKE ON AN INCEPTISOL

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ABSTRACT

This study aimed to determine the effect of applying *Trichoderma sp.*-enriched filter cake on the growth and yield of sweet corn, as well as soil organic-C content, in an Inceptisol soil. A Randomized Block Design with a single factor the dosage of *Trichoderma sp.*-enriched filter cake was employed, comprising four treatments and three replications. The treatments included a control without filter cake or *Trichoderma* (B0), and the application of filter cake at rates of 1.125 kg (B1), 2.25 kg (B2), and 3.375 kg per plot (B3), each enriched with 2 g of *Trichoderma sp.* The results indicated that the treatments significantly affected stem diameter, weight of husked cobs per plot, and soil organic-C content, but did not significantly affect cob weight per sample or weight of husked-free cobs per plot. Treatment B3 yielded a stem diameter of 20.36 mm, a husked cob weight of 6.31 kg per plot, and the highest soil organic-C content at 1.63%. Thus, B3 demonstrated the best response across several observed parameters. Increasing the filter cake dosage while maintaining a constant *Trichoderma* dosage has the potential to improve growth, yield, and soil organic-C content.

KEYWORDS: Filter cake, *Trichoderma sp.*, Sweet corn, Inceptisol, Soil organic carbon.

INTRODUCTION

Soil organic carbon (SOC) is a key indicator of soil quality, as it plays a vital role in maintaining the soil's physical, chemical, and biological functions while supporting crop productivity. A decline in SOC content resulting from agricultural intensification can compromise soil quality and the soil's ability to provide an optimal growing environment for crops. Consequently, organic matter management is a crucial strategy for maintaining soil quality and enhancing crop productivity. In maize cropping systems, the application of organic matter is known to improve soil physical and chemical properties, including aggregation, water-holding capacity, and SOC levels as well as crop growth and yield (Zhang et al., 2022; Abrol et al., 2024).

Inceptisols are widely utilized for agriculture; however, their fertility levels and SOC content vary spatially and are heavily influenced by land management practices. Managing organic matter in Inceptisols is essential, as sustained organic matter inputs can increase soil carbon content and support crop productivity. Research on Inceptisols indicates that applying organic fertilizer increases SOC, total nitrogen, and maize yield components compared to treatments without organic fertilizer, demonstrating a link between organic matter management, soil quality, and maize productivity (Sofyan & Yulyanti, 2023). Long-term studies on Inceptisols further show that integrating organic matter with mineral fertilizers can enhance SOC and soil quality while sustaining maize productivity (Abrol et al., 2024).

Sugarcane filter cake, a byproduct of sugarcane processing, is a potential source of organic matter for agricultural systems. Utilizing filter cake as a soil amendment holds significant value within a circular agriculture framework, as it returns organic matter and nutrients from the sugar industry to agricultural land. Composting sugar industry waste containing filter cake has been reported to improve soil properties and enhance crop productivity; furthermore, the application of filter cake compost shows potential for increasing inorganic fertilizer use efficiency in sugarcane crops (Nisi et al., 2024; Wibisana et al., 2020). Thus, filter cake has the potential to serve not only as a nutrient source but also as a source of carbon inputs that can influence soil organic carbon dynamics.

Soil organic carbon (SOC) dynamics following the addition of organic matter are determined not only by the amount of carbon entering the soil but also by processes of carbon decomposition, transformation, and stabilization. Easily decomposable organic matter can increase the more labile carbon fraction, whereas a portion of the carbon may undergo humification, contributing to the formation of more stable carbon fractions. Zhang et al. (2022) demonstrated that returning organic matter fermented with *Trichoderma reesei* could increase SOC and various carbon fractions compared to unfermented organic matter. These findings indicate that inoculation with decomposer microorganisms has the potential to alter organic matter transformation processes, thereby influencing the formation and accumulation of soil organic carbon.

Trichoderma represents a group of fungi widely utilized in soil and crop management due to their ability to interact with organic matter, soil microorganisms, and plant root systems. The use of *Trichoderma* in conjunction with organic matter can accelerate the transformation of organic matter and enhance nutrient availability for crops. In sugarcane cropping systems, a combination of residue management and *Trichoderma harzianum* inoculation has been reported to increase soil organic carbon, microbial biomass carbon, nutrient uptake, growth, and crop yield compared to management without inoculation (Shukla et al., 2022). Similarly, in maize cultivation, the use of *Trichoderma* alongside organic matter has been reported to improve soil nutrient status and support crop growth and yield (Zhang et al., 2022; Syamsiyah et al., 2024).

Crop response to organic matter does not always increase linearly with dosage. Insufficient amounts of organic matter may fail to provide adequate carbon and nutrient inputs, whereas increasing the dosage can lead to more substantial changes in soil properties. However, crop responses and soil properties may reach an optimum point because processes such as decomposition, nutrient availability, and changes in soil physical properties do not always proceed in direct proportion to the amount of organic matter applied. Research on maize indicates that

the responses of soil properties and plant growth to increasing organic matter dosages can be nonlinear; thus, determining the appropriate dosage is crucial for achieving a balance between soil improvement and crop productivity (Zhang et al., 2022). Recent studies using sugarcane filter cake compost also demonstrate that applying this material can influence maize growth, yield, and certain soil chemical properties, although the response depends on the material's composition and soil conditions (Manyanga et al., 2026).

Although the use of organic matter and *Trichoderma* has been studied separately, information regarding the response of soil organic carbon dynamics and sweet corn productivity to increasing doses of *Trichoderma*-enriched filter cake is still limited, especially in Inceptisol soil. Some previous studies have mainly evaluated the effect of organic fertilizer on plant yields or the effect of *Trichoderma* on plant growth and health, while the relationship between increasing filter cake doses, changes in soil organic carbon, and the simultaneous response to corn growth and yield has not been studied much. In fact, this approach is needed to determine whether increasing organic matter input through filter cake enriched with *Trichoderma* can provide agronomic benefits while improving soil carbon status.

Based on these considerations, this research was conducted to evaluate the dynamics of soil organic carbon, growth and yield of sweet corn in Inceptisol soil in response to the application of filter cake enriched with *Trichoderma*. The study used several levels of filter cake doses, while *Trichoderma* was given at the same dose in the filter cake-based treatment. The research hypothesis is that increasing the dose of *Trichoderma*-enriched filter cake will increase organic carbon input into the soil and result in changes in soil organic C content which will further support the growth and yield of sweet corn. This research is expected to provide an agronomic basis for the use of filter cake as a source of organic material as well as a strategy for managing soil carbon in Inceptisol.

MATERIALS AND METHODS

Research Location

The research was conducted at the experimental field of the Faculty of Agriculture, Islamic University of North Sumatra, Medan, Indonesia. The research site is located at an elevation of approximately 25 meters above sea level, featuring relatively flat topography and Inceptisol soil.

Research Design

The study employed a Randomized Block Design (RBD) with a single treatment factor: the application of filter cake enriched with *Trichoderma*. The treatments consisted of four levels: no filter cake and no *Trichoderma* (B0); filter cake at 1.125 kg/plot + *Trichoderma* at 2 g/plot (B1); filter cake at 2.250 kg/plot + *Trichoderma* at 2 g/plot (B2); and filter cake at 3.375

kg/plot + *Trichoderma* at 2 g/plot (B3). Each treatment was replicated three times, resulting in 12 experimental units. Each experimental unit consisted of a 1.5 m × 1.5 m (2.25 m²) plot. Consequently, the effective research area was 27 m², excluding the areas used for spacing between plots and experimental boundaries.

The filter cake dosages for treatments B1, B2, and B3 were equivalent to 0.5, 1.0, and 1.5 kg/m², respectively. *Trichoderma* was applied at a constant dosage of 2 g per plot (approximately 0.89 g/m²). Treatment B0 served as the control, with no application of filter cake or *Trichoderma*.

Blocking in the RBD was based on environmental conditions of the land that were expected to cause variability across different sections of the site. Each block contained all four treatments, which were assigned randomly.

Land and Growing Medium Preparation

The land was cleared of weeds and plant residues, and the soil was tilled to achieve a loose and relatively homogeneous condition. Tillage involved hoeing or working the soil to a depth suitable for maize root growth. Following tillage, the land was laid out into experimental plots measuring 1.5 m × 1.5 m, in accordance with the Randomized Block Design (RBD) layout.

Prior to treatment application, initial composite soil samples were collected from the soil layer serving as the plant root zone. These samples were cleared of roots and plant residues, then air-dried, pulverized, and prepared for soil organic-C analysis. The initial organic-C data served as a baseline to characterize the soil organic carbon status prior to treatment.

The filter cake used was a solid waste product from the sugarcane processing industry. It was weighed according to the dosage required for each treatment. For treatments B1, B2, and B3, the filter cake was evenly mixed with 2 g of *Trichoderma* per plot before application to the soil. This mixture was then applied uniformly across the surface of each plot and incorporated into the topsoil to ensure interaction between the organic material, the soil, and the plant root zone.

Sweet Corn Cultivation

Sweet corn seeds are planted once the land and treatments are ready. Planting involves creating holes spaced at 50 cm × 25 cm. A single seed is placed in each hole at a depth suitable for germination and early plant growth. Given a plot size of 1.5 m × 1.5 m and a planting spacing of 50 cm × 25 cm, the theoretical plant population per plot is approximately 18 plants. Plants along the plot edges serve as border plants, while those in the center serve as sample plants for monitoring growth and yield.

Plant Maintenance

Maintenance was carried out uniformly across all experimental units. Watering was performed to maintain water availability for the plants, particularly during the germination and early growth phases. The frequency and volume of watering were adjusted based on soil moisture conditions and rainfall throughout the study.

Replanting was conducted for plants that failed to grow or exhibited abnormal growth during the early growth stage. Replanting utilized plants of the same variety and seed source as the experimental plants. Weeding was performed manually by pulling out or clearing weeds growing within the plots. Pest and disease control measures were implemented whenever infestations or infections were detected that could potentially hinder plant growth and yield.

Plant Growth Observation

Growth observations were conducted periodically on sample plants in each plot. The growth parameters observed included:

Plant height

Plant height was measured from the soil surface to the growing point or the highest fully unfolded leaf. Measurements were taken using a tape measure or ruler and expressed in centimeters (cm). Measurements were performed at consistent time intervals across all treatments.

Stem diameter

Stem diameter was measured using a caliper at a specific stem location consistently selected for all sample plants. Results were expressed in millimeters (mm). Measurements were taken at the same observation times for all treatments.

Soil organic C observation

Soil organic C analysis was performed twice: before treatment application and after plant harvest. Initial soil samples were collected prior to filter cake application, while final samples were taken after harvest from each treatment plot at the same soil depth as the initial sampling. Soil samples were air-dried, cleared of roots and coarse material, then ground and sieved prior to analysis. Soil organic C content was analyzed using the Walkley–Black method, involving the oxidation of organic carbon by potassium dichromate under acidic conditions. Results were expressed as a percentage of organic C (%). Changes in soil organic C content were calculated based on the difference between post-treatment and pre-treatment values: $\Delta\text{Organic C} = \text{Final Organic C} - \text{Initial Organic C}$.

A positive value indicates an increase in soil organic C content during the study period, whereas a negative value indicates a decrease.

Harvest

Sweet corn was harvested at a stage of maturity suitable for fresh consumption, characterized by the condition of the ears and kernels having reached the milk stage. Harvesting was carried out at approximately the same time for all treatments. Ears were picked from sample plants and plants located within the harvest area of each plot. After harvesting, the ears were cleaned of unwanted parts, and their weights were measured according to the predetermined yield components.

Yield Parameters

Weight of ear with husk per sample

Ears harvested from sample plants were weighed with their husks using a digital scale. Weight is expressed in grams (g) per ear or as the average ear weight per sample plant.

Weight of ears with husks per plot

All ears harvested from the harvest area of each plot were weighed with their husks. Results are expressed in kilograms (kg) per plot.

Weight of ears without husks per sample

The husks were removed from the ears of sample plants, and the ears were then weighed using a digital scale. Weight is expressed in grams (g) per ear or as the average weight of ears without husks per sample plant.

Weight of ears without husks per plot

All ears from the harvest area of each plot were husked and then weighed. Weight is expressed in grams (g) per plot.

Data Analysis

Data on growth, yield, and soil organic C were analyzed using analysis of variance (ANOVA) based on a Randomized Complete Block Design model. If the ANOVA results indicated a significant treatment effect,

mean comparison tests were conducted according to the applied significance level. Analysis of soil organic C involved comparing organic C content before and after treatment and evaluating changes in organic C for each treatment. All statistical analyses were performed at a 5% significance level ($\alpha = 0.05$) using the LSD test.

RESULTS AND DISCUSSION

Initial Soil Conditions

Pre-treatment soil analysis results indicated that the soil used in the study possessed relatively low chemical fertility, characterized primarily by low levels of organic C, total N, available P, and exchangeable K (Table 1). This initial condition is a crucial factor to consider, as the study aimed to evaluate the capacity of *Trichoderma*-enriched filter cake to improve soil organic carbon while simultaneously supporting sweet corn growth and yield.

A soil organic carbon (SOC) content of 0.38% falls into the "very low" category, indicating limited organic matter reserves. SOC is a crucial component for maintaining soil quality, as it plays a vital role in aggregate formation, water-holding capacity, cation exchange capacity, and the supply and storage of nutrients. Such a low SOC level suggests that organic matter inputs into the soil have likely been insufficient to offset carbon losses resulting from decomposition and other processes. This situation provides a strong rationale for using filter cake as an organic matter source in this study. Applying organic matter to the soil can increase SOC and improve various soil properties, provided that carbon inputs are adequate and sustained. Long-term studies have demonstrated that organic matter application can enhance SOC as well as the carbon and nitrogen associated with soil aggregates (Ma et al., 2024). In maize cropping systems, organic matter management has also been reported to improve soil quality and crop productivity.

Table 1: Initial soil chemical properti.

Parameter	Initial value	Status	Key implication
C-organik	0.38%	Very low	Soil organic matter and carbon reserves are very limited
N-total	0.07%	Low	Potential nitrogen (N) limitation for vegetative growth
P-Available	1.75 ppm	Low	Potential phosphorus (P) limitation, especially for root and early-stage development
K-dd	0.29 me/100 g	Low	Potential potassium (K) limitation for water regulation and photosynthate translocation
pH H ₂ O	5.47	Acid/slightly acid	Can limit phosphorus (P) availability and affect nutrient dynamics

Sumber: Analysis Results from the Testing Laboratory of the Assessment Institute for Agricultural Technology (BPTP) North Sumatra, Indonesia

The total nitrogen (N-total) content of 0.07% is considered low. This low level indicates that soil nitrogen reserves are relatively limited. Nitrogen is an essential macronutrient that plays a key role in the formation of chlorophyll, proteins, and nucleic acids, as

well as in vegetative tissue development. Consequently, low initial N levels could potentially limit maize vegetative growth unless additional N is supplied through fertilizers or the mineralization of organic matter. The relationship between soil N status and maize

productivity is also highlighted by long-term studies, which have found that soil fertility factors, including soil organic carbon (SOC) and total N play a crucial role in explaining variations in maize yields.

The available phosphorus (P-available) content of 1.75 ppm is classified as low. This value indicates that the majority of soil phosphorus exists in forms that are relatively unavailable to plants or is bound to soil components. Phosphorus availability is critical during the early stages of maize growth, as it is linked to root development, energy transfer, and the formation of reproductive organs. Low P levels are particularly relevant in acidic soils, where phosphorus can be fixed by iron (Fe) and aluminum (Al) minerals, thereby reducing the fraction of P available to plants. In a study on Inceptisols used for maize cultivation, Chairuman et al. (2023) also reported low soil chemical fertility and emphasized the importance of P and K management to support maize growth and production. That study recorded a Bray I P level of 1.65 ppm in Inceptisol soil, a value very close to the initial level observed in the present study (1.75 ppm).

An exchangeable potassium (K-dd) content of 0.29 me/100 g indicates that the level of exchangeable potassium in the soil is low. Potassium is a crucial element for osmotic regulation, enzyme activation, water balance, photosynthate translocation, and enhancing plant resilience against environmental stress. Low K availability has the potential to limit growth and yield formation if crop requirements are not met by an adequate K supply. Interestingly, the initial K-dd value of 0.29 me/100 g in this study is identical to the K-dd value reported by Chairuman et al. (2023) for an Inceptisol in Langkat (0.29 me/100 g). That study demonstrated that appropriate P and K management could increase maize productivity on Inceptisols. The pH of 5.47 may also help explain the low level of available P; in acidic soils, phosphate can interact with Fe and Al to form compounds with low solubility, thereby reducing P availability to plants. Research on Inceptisols indicates that changes in soil chemical properties, including available P, are linked to soil reaction conditions. Increases or decreases in P availability need to be understood in the context of pH changes and the interaction of P with soil components.

Overall, the soil at the start of the study was characterized by very low organic C, low total N, low

available P, and low exchangeable K, with an acidic reaction (pH 5.47). This profile indicates that the soil faced limitations primarily regarding organic matter supply and the availability of certain macronutrients. These conditions provided a solid agronomic basis for evaluating the application of *Trichoderma*-enriched filter cake. Filter cake has the potential to supply carbon and nutrients, while *Trichoderma* can facilitate organic matter transformation and nutrient cycling. Research on Inceptisols has shown that organic matter application can enhance the activity of microorganisms involved in N and P cycling and improve nutrient uptake in maize (Usman et al., 2024). Consequently, changes in organic C levels following treatment serve as a crucial parameter for determining whether increasing filter cake dosages effectively improves soil carbon status and subsequently influences the growth and yield responses of sweet corn.

Given these initial conditions, the organic C response following filter cake application is a key factor in assessing treatment effectiveness. An increase in organic C content post-treatment can be interpreted as an indication of carbon addition and retention derived from the applied organic matter. However, an increase in organic C does not automatically imply increased productivity, as crop response is also governed by the availability of N, P, and K, soil pH, organic matter mineralization, and soil biological processes. Therefore, the interpretation of organic C levels in this study should be considered alongside changes in sweet corn growth and yield components.

Sweet Corn Growth

1. Plant Height (cm)

The application of *Trichoderma*-enriched filter cake significantly affected the plant height of sweet corn. The average plant heights were 87.75 cm for B0 (no filter cake and no *Trichoderma*), 98.42 cm for B1 (1.125 kg filter cake/plot + 2 g *Trichoderma*/plot), 99.15 cm for B2 (2.250 kg filter cake/plot + 2 g *Trichoderma*/plot), and 101.33 cm for B3 (3.375 kg filter cake/plot + 2 g *Trichoderma*/plot). Mean comparison results indicated that B3 produced the greatest plant height, differing significantly from B0, whereas B1 and B2 did not differ significantly from either B0 or B3 (Table 2). This pattern suggests that increasing the dosage of *Trichoderma*-enriched filter cake tended to enhance plant height growth; however, the plant response did not show consistent differences with each dosage increment.

Table 2: Plant height (cm) of sweet corn treated with *Trichoderma*-enriched filter cake.

Treatment	Plant height (cm)	Change vs B0	Notation
B0 – no filter cake	87.75	–	b
B1 – 1.125 kg + <i>Trichoderma</i>	98.42	+12.18%	ab
B2 – 2.250 kg + <i>Trichoderma</i>	99.15	+13.00%	ab
B3 – 3.375 kg + <i>Trichoderma</i>	101.33	+15.47%	a

Note: Different notations indicate that the applied treatments differed significantly at the 5% level based on the LSD test.

Plants under treatment B3 reached a height of 101.33 cm, representing an increase of approximately 15.47% compared to B0. Meanwhile, treatments B1 and B2 increased plant height by approximately 12.18% and 13.00%, respectively, compared to the control (B0). Thus, the greatest numerical response was observed with the application of 3.375 kg/plot of filter cake combined with 2 g/plot of *Trichoderma* (B3). This increase in plant height indicates that the addition of *Trichoderma*-enriched filter cake created conditions more favorable for the vegetative growth of sweet corn than the absence of filter cake application.

This response can be attributed to the relatively low initial soil fertility levels, specifically, organic C at 0.38%, total N at 0.07%, available P at 1.75 ppm, and exchangeable K at 0.29 me/100 g. Under such conditions, the addition of organic matter has the potential to increase nutrient supply through mineralization while simultaneously improving the root zone environment. Filter cake contains organic matter and various nutrients that can contribute to enhanced soil fertility. Research by Setiaji et al. (2023) demonstrated that fertilizers based on sugarcane filter cake elicit a positive vegetative growth response in sweet corn, including in terms of plant height and stem diameter. In that study, filter cake-based fertilizers were among the treatments yielding the best vegetative growth performance.

Trichoderma plays a role in enhancing this process through its interactions with organic matter and the root zone environment. These microorganisms contribute to the transformation of organic matter and increase nutrient availability, making certain nutrients more readily accessible to plants. Syamsiyah et al. (2024) demonstrated that the application of *Trichoderma* alongside NPK fertilizer increased total soil N by 84.21%, available P by 36.25%, and available K by 142.22%; this increase in nutrient availability was accompanied by enhanced N, P, and K uptake in maize plants. These findings suggest that the presence of *Trichoderma* in fertilization systems can contribute to improving the nutrient environment, thereby supporting maize growth.

These results are also consistent with the study by Kusparwanti et al. (2022) on sweet corn, which showed that the application of *Trichoderma*-enriched organic fertilizer influenced plant growth, particularly at 28 and 42 days after planting. That study utilized various types of *Trichoderma*-enriched organic fertilizers and demonstrated that *Trichoderma*-based organic matter management could yield better growth responses compared to control treatments during specific growth phases.

The pattern of increasing plant height from B0 to B3 is also supported by recent research on the use of sugarcane

filter cake for maize. Manyanga et al. (2026) reported that the application of sugarcane filter cake compost elicited a positive growth response in maize, with specific filter cake treatments yielding taller plants compared to treatments without soil amendments. Variations in response across dosages or formulations indicate that the effectiveness of filter cake is determined not only by the presence of organic matter but also by material characteristics, dosage, soil conditions, and nutrient availability.

Biologically, the increase in plant height observed in treatments receiving filter cake can be attributed to the enhanced availability of carbon sources and nutrients in the root zone. Organic carbon plays a crucial role in maintaining soil environmental quality, while the decomposition of organic matter releases nutrients in forms more readily available to the plant. Concurrently, *Trichoderma* can facilitate decomposition processes and rhizosphere interactions that promote root development and nutrient uptake. These conditions ultimately foster vegetative tissue formation and plant elongation.

However, the increase in plant height did not exhibit a strong linear relationship across all dosages. Plant height rose from 87.75 cm (B0) to 98.42 cm (B1), followed by only slight increases to 99.15 cm (B2) and 101.33 cm (B3). Numerically, the increase from B1 to B2 was approximately 0.74%, while the rise from B2 to B3 was about 2.20%. This indicates a trend of diminishing response as the filter cake dosage increased. In other words, increasing the filter cake application from 1.125 to 2.250 kg/plot and subsequently to 3.375 kg/plot did not result in plant height gains proportional to the increase in dosage. These findings are significant when considered alongside the results of soil organic carbon (SOC) analysis. The soil initially had very low organic carbon levels; thus, the addition of filter cake provided a new carbon source. If the final analysis reveals an increase in SOC that rises in tandem with the filter cake dosage, a stronger relationship can be established linking organic matter input, changes in SOC, nutrient availability or the root zone environment, and vegetative maize growth. However, this relationship should not be characterized as a direct cause-and-effect link without further nutrient analysis or an assessment of the correlation between SOC changes and plant height.

2. Stem Diameter (mm)

The application of *Trichoderma*-enriched filter cake significantly affected the stem diameter of sweet corn. The mean stem diameters were 18.27 mm for B0, 19.77 mm for B1, 20.12 mm for B2, and 20.36 mm for B3. Based on mean comparison test results, treatments B2 and B3 produced significantly larger stem diameters than B0, whereas B1 did not differ significantly from B0, B2, or B3 (Table 3).

Tabel 3: Stem diameter (mm) of sweet corn with the application of *Trichoderma*-enriched filter cake.

Treatment	Plant height (cm)	Increase relative to B0	Notation
B0 – No filter cake	18.27	—	b
B1 – 1.125 kg + <i>Trichoderma</i>	19.77	8.21%	ab
B2 – 2.250 kg + <i>Trichoderma</i>	20.12	10.13%	a
B3 – 3.375 kg + <i>Trichoderma</i>	20.36	11.44%	a

Note: Different notations indicate that the applied treatments differed significantly at the 5% level based on the LSD test.

Numerically, stem diameter increased with increasing rates of *Trichoderma*-enriched sugarcane filter cake. Compared with B0, stem diameter increased by 1.50 mm (8.21%) in B1, 1.85 mm (10.13%) in B2, and 2.09 mm (11.44%) in B3. The highest stem diameter was recorded in B3 (20.36 mm), although this treatment was not significantly different from B2. This finding indicates that increasing the filter cake rate from 2.25 to 3.375 kg/plot did not produce a sufficiently large increase in stem diameter to result in a statistically significant difference.

The increase in stem diameter in treatments receiving filter cake may be attributed to the additional organic matter and nutrients supplied to the soil. The initial soil analysis indicated very low organic carbon content (0.38%), low total nitrogen (0.07%), low available phosphorus (1.75 ppm), and low exchangeable potassium (0.29 me/100 g). Under these conditions, filter cake application could potentially increase the supply of organic matter and nutrients in the root zone. Improved nutrient availability may support the development of vegetative tissues, including stem growth. A relationship between filter cake application and vegetative growth in maize was also reported by Setiaji et al. (2023). Their study specifically evaluated sweet maize growth under different fertilizer formulations based on sugarcane filter cake and found that filter cake-based fertilizers promoted strong vegetative performance. Stem diameter was explicitly measured, and the filter cake treatments produced larger stem diameters than the control.

These findings provide relevant support for the present study because both investigations used sweet maize and sugarcane filter cake as the primary organic material. Setiaji et al. (2023) reported a stem diameter of approximately 4.59 mm in the control, whereas filter cake treatments at different application rates produced stem diameters of up to approximately 15.22 mm. This response suggests that filter cake can contribute to improved vegetative growth in maize through the provision of organic matter and nutrients. However, the magnitude of the response cannot be compared directly with that observed in the present study because the application rates, fertilizer formulations, soil conditions, and observation periods differed.

The inclusion of *Trichoderma* in the treatments may have further enhanced the utilization of the applied organic material. *Trichoderma* can interact with organic substrates and the rhizosphere environment, potentially

contributing to organic matter transformation and nutrient availability. A study by Kusparwanti et al. (2022) on sweet maize demonstrated that organic fertilizers enriched with *Trichoderma* could influence plant growth and yield. The study evaluated several types of organic fertilizers enriched with *Trichoderma* and indicated that combining organic amendments with this beneficial fungus represents a promising approach to improving sweet maize performance.

Further support comes from Syamsiyah et al. (2024), who reported that *Trichoderma* application in maize cropping systems could increase the availability of certain soil nutrients and nutrient uptake by plants. Improved plant nutrient status may, in turn, support vegetative biomass production. Accordingly, the increase in stem diameter observed in the present study may be interpreted as a growth response to improved root-zone conditions following the application of *Trichoderma*-enriched filter cake. Nevertheless, because nitrogen, phosphorus, and potassium uptake and soil microbial activity were not measured in this study, these explanations should be regarded as plausible mechanisms rather than mechanisms directly demonstrated by the experimental results.

The response pattern across treatments also indicated diminishing incremental gains at higher filter cake application rates. Stem diameter increased by 8.21% from B0 to B1, whereas the subsequent increases were approximately 1.77% from B1 to B2 and 1.19% from B2 to B3. Thus, most of the increase in stem diameter occurred when filter cake and *Trichoderma* were introduced, compared with the untreated control. Once the application rate reached B2, further additions of filter cake resulted in only marginal increases in stem diameter. This pattern may indicate that stem growth was approaching a response plateau at an application rate of 2.25 kg filter cake/plot.

Although B3 produced the numerically largest stem diameter, B2 was statistically comparable to B3. This finding is important because increasing the filter cake rate from 2.25 to 3.375 kg/plot did not provide a statistically significant additional benefit in stem growth. From the perspective of organic amendment efficiency, B2 may therefore represent a more efficient application rate than B3 if yield-related parameters exhibit a similar response pattern.

The difference in response between B1 and B2 is also noteworthy. B1 produced a stem diameter of 19.77 mm, which was not significantly different from that of B2 (20.12 mm). This result suggests that increasing the filter cake rate from 1.125 to 2.25 kg/plot produced a relatively small numerical increase in stem diameter, while B2 remained statistically comparable to B3. The statistical grouping of B1, B2, and B3 should, however, be interpreted according to the actual multiple-comparison results. Based on stem diameter alone, the application rate of 2.25 kg filter cake plus 2 g *Trichoderma*/plot represents a potentially important rate for improving vegetative growth.

When considered alongside plant height, stem diameter exhibited a broadly consistent response pattern. Both parameters increased from B0 to B3. However, the statistical results differed between the two parameters: B2 was already in the highest statistical group for stem diameter, whereas B3 produced the greatest plant height and differed significantly from B0. The consistent direction of these responses suggests that *Trichoderma*-enriched filter cake generally provided more favorable growing conditions for sweet maize than the untreated control.

Overall, the results indicate that applying *Trichoderma*-enriched sugarcane filter cake increased sweet maize stem diameter in an Inceptisol with relatively low initial fertility. Treatments B2 (2.25 kg filter cake + 2 g *Trichoderma*/plot) and B3 (3.375 kg filter cake + 2 g

Trichoderma/plot) produced stem diameters that were statistically higher than that of B0. Although B3 had the highest numerical value, it was not significantly different from B2. Therefore, based on stem diameter, an application rate of 2.25 kg filter cake/plot was sufficient to achieve a response statistically comparable to that obtained with 3.375 kg/plot. These findings support the possibility that *Trichoderma*-enriched filter cake can improve growing conditions in soils with low initial organic carbon and nutrient availability. However, identifying the most agronomically appropriate treatment requires interpreting stem diameter alongside changes in soil organic carbon, plant height, yield components, and ear weight. The superiority of an application rate should therefore be assessed not only in terms of vegetative growth but also its ability to improve sweet maize productivity and soil carbon status.

Sweet Corn Crop Yield

1. Ear Weight with Husks per Sample (g)

The weight of sweet corn ears (including husks) per sample ranged from 367.25 to 431.67 g. The treatment without the application of *Trichoderma*-enriched filter cake (B0) resulted in the lowest ear weight (367.25 g), whereas the highest weight was obtained with treatment B3 (431.67 g). Treatments B1 and B2 yielded weights of 373.89 g and 410.56 g, respectively (Table 4). Thus, there was a numerical trend of increasing ear weight (including husks) corresponding to the increased dosage of *Trichoderma*-enriched filter cake.

Table 4: Weight of sweet corn ears (including husks) per sample (g) with the application of *Trichoderma*-enriched filter cake.

Treatments	Ear Weight with Husks per Sample	Increase relative to B0
B0 – no filter cake	367.25	—
B1 – 1.125 kg + <i>Trichoderma</i>	373.89	1.81%
B2 – 2.250 kg + <i>Trichoderma</i>	410.56	11.80%
B3 – 3.375 kg + <i>Trichoderma</i>	431.67	17.55%

Note: The absence of notation indicates that the treatment effect was not significant.

Compared with B0, ear weight increased by 6.64 g (1.81%) in B1, 43.31 g (11.80%) in B2, and 64.42 g (17.55%) in B3. However, because the statistical analysis indicated that the treatment effect was not significant, these numerical increases cannot be interpreted as statistically consistent treatment responses. In other words, the observed differences in ear weight may reflect biological variation among plants or experimental variability and are insufficient to conclude that increasing the application rate of *Trichoderma*-enriched filter cake significantly increased ear weight with husks.

The absence of a significant treatment effect may be associated with the nature of ear weight as a yield component that develops during the reproductive phase and is influenced by biomass accumulation and assimilate partitioning during ear development and grain filling. Improvements in soil conditions and vegetative

growth resulting from organic amendments do not necessarily translate into significant increases in yield components. In the present study, although *Trichoderma*-enriched filter cake treatments showed a tendency toward increased ear weight, variability among individual plants may have been sufficiently large to prevent the differences among treatment means from reaching statistical significance.

Nevertheless, the results reveal an interesting biological trend. The increases in ear weight from B1 to B2 and B3 were considerably greater than the increase from B0 to B1. Treatment B3 produced an ear weight of 431.67 g, which was 17.55% higher than that of B0. This pattern suggests a positive numerical response to increasing filter cake application rates; however, the response was not sufficiently consistent to produce statistically significant differences. Therefore, the results should be

described using terms such as a tendency toward an increase, a numerical increase, or a positive numerical trend, rather than claiming that the treatments significantly increased ear weight.

The findings of Setiaji et al. (2023) provide relevant supporting evidence because their study also used sweet maize and sugarcane filter cake as the primary material for fertilizer formulation. The application of filter cake-based fertilizers improved several agronomic characteristics of maize, including vegetative growth and biomass accumulation. These findings indicate that filter cake has potential as a source of organic matter and nutrients that can support maize growth. However, the results cannot be used to conclude that filter cake necessarily increases ear weight in the present study because the fertilizer formulations, application rates, soil conditions, and experimental environments differed.

Similarly, Kusparwanti et al. (2022) reported that organic fertilizers enriched with *Trichoderma sp.* could influence yield components in sweet maize. Their study identified goat manure enriched with *Trichoderma* as the treatment producing the best results for ear weight. This finding supports the possibility that combining organic amendments with *Trichoderma* may contribute to sweet maize yield formation. Nevertheless, because the organic material used in that study differed from the filter cake applied in the present experiment, the findings are more appropriately interpreted as evidence supporting the general role of organic amendment-*Trichoderma* combinations rather than as a direct comparison of ear weight responses.

More specific evidence regarding ear weight with husks was reported in a 2025 study of sweet maize treated with filter cake and NPK fertilizer. The combined application of filter cake at 1,000 kg/ha and NPK fertilizer at 400 kg/ha produced an ear weight with husks of 301.3 g per sample and was among the treatments with the best results. These findings indicate that filter cake may contribute to sweet maize yield formation. However, yield responses depend strongly on the combination of application rates, nutrient sources, soil properties, and environmental conditions.

Interestingly, a recent study investigating different application rates of *Trichoderma* in sweet maize also reported a significant increase in ear weight with husks at the highest application rate. However, that study used

Trichoderma as a standalone treatment, whereas the present study maintained the same *Trichoderma* application rate across B1-B3, with the principal difference among these treatments being the amount of filter cake applied. Consequently, the findings of that study cannot be used to attribute the ear weight response observed in the present experiment solely to *Trichoderma*.

Overall, the results indicate that applying *Trichoderma*-enriched filter cake resulted in a numerical tendency toward increased ear weight with husks per sample, with the highest value recorded in B3 at 431.67 g, representing a 17.55% increase relative to B0. However, because the differences were not statistically significant, this increase cannot be regarded as a significant treatment effect. The findings suggest that filter cake application may support ear development, although the response of this yield component remains subject to plant-to-plant variability and experimental conditions. Therefore, the most scientifically defensible conclusion is that *Trichoderma*-enriched filter cake did not significantly increase ear weight with husks per sample, despite a numerical tendency toward higher values at greater filter cake application rates.

2. Ear weight with husks per plot (kg)

The weight of sweet corn ears (including husks) per plot indicates that the application of *Trichoderma*-enriched filter cake significantly affects crop yield. The average weights per plot were 5.33 kg for B0, 5.61 kg for B1, 6.20 kg for B2, and 6.31 kg for B3. Mean comparison tests showed that B2 and B3 produced significantly higher ear weights per plot compared to B0, whereas B1 did not show a significant difference compared to either B0 or the B2 and B3 treatments (Table 4).

Numerically, the application of *Trichoderma*-enriched filter cake increased the weight of ears per plot compared to the untreated control. The increase for B1 was 0.28 kg (5.25%) relative to B0, while B2 and B3 showed increases of 0.87 kg (16.32%) and 0.98 kg (18.39%), respectively. Treatment B3 yielded the highest weight at 6.31 kg per plot; however, this did not differ significantly from B2, which yielded 6.20 kg per plot. Thus, statistically, B2 produced an ear weight comparable to that of B3, indicating that increasing the filter cake dosage from B2 to B3 did not yield a significant additional benefit.

Table 4: Weight of sweet corn ears with husks per plot (kg) with the application of filter cake enriched with *Trichoderma*.

Treatments	Ear weight with husks per plot	Increase relative to B0	Notation
B0 – No filter cake	5.33	—	b
B1 – 1.125 kg + <i>Trichoderma</i>	5.61	5.25%	ab
B2 – 2.250 kg + <i>Trichoderma</i>	6.20	16.32%	a
B3 – 3.375 kg + <i>Trichoderma</i>	6.31	18.39%	a

Note: Different notations indicate that the applied treatments differed significantly at the 5% level based on the LSD test.

This response suggests that the application of *Trichoderma*-enriched filter cake has the potential to improve growing conditions in Inceptisol soils with relatively low initial fertility. The initial soil analysis indicated an organic carbon content of 0.38%, total nitrogen of 0.07%, available phosphorus of 1.75 ppm, and exchangeable potassium of 0.29 me/100 g, indicating low organic matter content and limited availability of several essential nutrients. Filter cake application can supply organic matter and certain nutrients, potentially improving soil chemical properties and supporting plant growth and yield formation. In this context, *Trichoderma* may also contribute to organic matter transformation and nutrient availability. However, because microbial activity and the mechanisms governing nutrient release were not directly measured in this study, these processes should be presented as plausible explanations rather than mechanisms demonstrated by the experimental results.

The findings of the present study are consistent with those of Khatizah et al. (2025), who investigated sweet maize treated with filter cake and NPK fertilizer. Their study reported that the combination of filter cake at 1,000 kg/ha and NPK fertilizer at 350 kg/ha produced an ear weight with husks of 5.2 kg/plot, whereas the combination of filter cake at 1,000 kg/ha and NPK fertilizer at 400 kg/ha resulted in an ear weight with husks of 301.3 g per sample. These findings indicate that filter cake can contribute to sweet maize yield formation, although the response depends on the combination and application rates of the nutrient sources. This evidence is relevant to the numerical increase in ear weight observed in treatments B2 and B3 in the present study.

Broader supporting evidence is provided by Setiaji et al. (2023), who specifically evaluated sugarcane filter cake-based fertilizers in sweet maize. Their study demonstrated that filter cake-based fertilizers could improve sweet maize growth characteristics, including vegetative traits associated with plant biomass accumulation. Greater vegetative growth and biomass accumulation may increase the plant's capacity to allocate assimilates to reproductive organs. Nevertheless, these findings do not establish that filter cake consistently increases yield by the same magnitude under all conditions, as fertilizer formulations, application rates, soil properties, and environmental conditions differ from those of the present study.

Research on organic fertilizers enriched with *Trichoderma* in sweet maize also provides a relevant biological basis for interpreting the results. Kusparwanti et al. (2022) reported growth and yield responses in sweet maize following the application of organic fertilizers enriched with *Trichoderma sp.* These findings support the possibility that combining organic amendments with *Trichoderma* may contribute to yield formation. However, the effects reported in that study should not be assumed to be identical to those of filter

cake in the present experiment because the organic materials and experimental conditions differed.

The difference between the nonsignificant treatment effect on ear weight with husks per sample and the significant effect on ear weight with husks per plot also warrants consideration. Ear weight per sample represents only a subset of harvested ears, meaning that variation in ear size among sampled plants may be relatively large. In contrast, ear weight per plot integrates the production of ears from plants within an experimental unit and therefore more directly represents yield at the plot level. Consequently, a treatment may produce a significant difference in ear weight per plot even when differences in the mean weight of sampled ears are not statistically significant. However, this explanation represents a statistical and biological interpretation and does not establish that the observed differences were necessarily attributable to greater plant uniformity. Additional information on the number of productive plants and the distribution of ear sizes would be required to substantiate that explanation.

The response pattern in B2 and B3 also suggests that the yield response may have begun to plateau at higher filter cake application rates. Ear weight increased by 16.32% from B0 to B2, whereas increasing the application rate from B2 to B3 resulted in an additional increase of only approximately 1.77%. Because B2 and B3 were not significantly different, B2 may be considered a potentially more agronomically efficient treatment than B3, particularly if the higher filter cake application rate entails additional application costs. However, economic efficiency cannot be established without information on filter cake prices, application costs, and the market value of sweet maize yield.

Overall, the application of *Trichoderma*-enriched filter cake had a significant effect on sweet maize ear weight with husks per plot. Treatments B2 and B3 produced ear weights of 6.20 and 6.31 kg/plot, respectively, representing increases of approximately 16.32-18.39% relative to B0, which produced 5.33 kg/plot. Although B3 recorded the highest numerical value, its ear weight was not significantly different from that of B2. These findings indicate that the B2 application rate was sufficient to achieve a yield response statistically comparable to that obtained with B3. Therefore, increasing the filter cake application rate beyond B2 did not result in a statistically significant additional yield benefit.

3. Weight of Husk-free Ear per Sample (g)

The weight of husked ears per sweet corn sample indicated that the application of *Trichoderma sp.*-enriched filter cake did not have a statistically significant effect on the observed parameter. Although the treatment effect was not statistically significant, the numerical values for husked ear weight per sample were 286.67 g

for B0, 296.39 g for B1, 317.50 g for B2, and 333.06 g for B3 (Table 5).

A trend of increasing husked ear weight was observed alongside the increase in filter cake dosage. Compared to B0, treatment B1 increased ear weight by 9.72 g (3.39%), B2 by 30.83 g (10.76%), and B3 by 46.39 g

(16.19%). Consequently, treatment B3 yielded the highest numerical husked ear weight (333.06 g), while B0 yielded the lowest (286.67 g). However, since the differences were not statistically significant, the 16.19% increase observed in B3 cannot yet be cited as evidence that the application of *Trichoderma*-enriched filter cake consistently increases husked ear weight per sample.

Table 5: Husked ear weight per sample (g) of sweet corn treated with *Trichoderma*-enriched filter cake.

Treatments	Weight of Husk-free Ear per Sample	Increase relative to B0
B0 – No filter cake	286.67	—
B1 – 1.125 kg + <i>Trichoderma</i>	296.39	3.39%
B2 – 2.250 kg + <i>Trichoderma</i>	317.50	10.76%
B3 – 3.375 kg + <i>Trichoderma</i>	333.06	16.19%

Note: The absence of notation indicates that the treatment effect was not significant.

The nonsignificant treatment effect on dehusked ear weight per sample indicates that ear development and grain filling at the individual plant level may still have been influenced by plant-to-plant variability. Ear weight is the outcome of several processes, including ear formation, kernel number and development, and assimilate accumulation during the reproductive phase. Increased organic matter and nutrient availability do not necessarily result in a significant increase in the weight of individual ears, particularly when other factors influencing yield formation, such as pollination success, kernel set, and the plant's capacity to allocate assimilates to the ears, also play important roles.

The tendency toward increased ear weight from B0 to B3 nevertheless suggests that filter cake application may support yield formation in sweet maize. This finding is relevant to the relatively low initial soil fertility observed in the present study. Filter cake is a residue from the sugar industry that contains organic matter and nutrients; therefore, its use as a soil amendment or organic matter source may improve soil conditions and support plant growth. Setiaji et al. (2023) demonstrated that sugarcane filter cake-based fertilizer formulations could improve the agronomic performance of sweet maize and several indicators of soil quality. Their findings also indicated that plant responses depended on the fertilizer formulation and application rate.

The findings of Khatizah et al. (2025) provide a more direct comparison because their study also investigated filter cake application in sweet maize. They reported that the combination of filter cake at 1,000 kg/ha and NPK fertilizer at 400 kg/ha produced a dehusked ear weight of 252.5 g per sample. Notably, their statistical analysis also indicated that the treatment effect on dehusked ear weight per sample was nonsignificant, even though the treatment effect on ear weight with husks was significant. This pattern is highly relevant to the present study, as it demonstrates that numerical changes in ear weight do not necessarily translate into statistically significant differences in dehusked ear weight.

These findings also highlight the possibility that ear weight responses may differ depending on whether husks are included in the measurement. Husks contribute to total ear weight when measurements are taken before dehusking, whereas dehusked ear weight primarily reflects the combined weight of the cob and kernels. Consequently, an increase in ear weight with husks does not necessarily correspond to an increase of the same magnitude in dehusked ear weight. In the study by Khatizah et al. (2025), for example, ear weight with husks responded significantly to the treatment combinations, whereas dehusked ear weight did not.

Kusparwanti et al. (2022) reported that organic fertilizers enriched with *Trichoderma sp.* could influence sweet maize growth and yield, with *Trichoderma*-enriched goat manure producing the most favorable response in ear weight. These findings support the possibility that combining organic amendments with *Trichoderma* may contribute to yield formation. However, because their study used a different organic material, its results cannot establish that *Trichoderma* specifically caused an increase in ear weight in the present experiment.

Overall, the application of *Trichoderma*-enriched filter cake resulted in a numerical tendency toward increased dehusked ear weight per sample, from 286.67 g in B0 to 333.06 g in B3. The largest numerical increase was 16.19% in B3 relative to B0; however, the treatment effect was not statistically significant. Therefore, the results suggest that increasing the filter cake application rate may promote greater dehusked ear weight, but the response at the sample level was not sufficiently consistent to produce statistically significant differences. This finding is consistent with previous research indicating that dehusked ear weight may respond less strongly than ear weight with husks to filter cake application (Khatizah et al., 2025).

4. Weight of Husk-free Ears per Plot (kg)

The weight of husked sweet corn ears per plot ranged from 4.34 to 4.95 kg. Treatment B0 yielded the lowest weight at 4.34 kg/plot, followed by B1 at 4.35 kg/plot, B2 at 4.71 kg/plot, and B3 at 4.95 kg/plot. Numerically,

there was a trend of increasing husked ear weight corresponding to the increased dosage of *Trichoderma* sp.-enriched filter cake. Compared to B0, the weight increased by 0.23% for B1, 8.53% for B2, and 14.06% for B3. Although B3 produced the highest value,

statistical analysis indicated that the treatment effect was not significant. Therefore, these numerical increases cannot be considered statistically significant yield improvements (Table 6).

Table 6: Weight of husked sweet corn ears per plot (kg) with the application of *Trichoderma*-enriched filter cake.

Treatments	Weight of Husk-free Ears per Plot	Increase relative to B0
B0 – No filter cake	4.34	—
B1 – 1.125 kg + <i>Trichoderma</i>	4.35	0.23%
B2 – 2.250 kg + <i>Trichoderma</i>	4.71	8.53%
B3 – 3.375 kg + <i>Trichoderma</i>	4.95	14.06%

Note: The absence of notation indicates that the treatment effect was not significant.

The nonsignificant treatment effect indicates that variation in dehusked ear weight among plots or individual plants was relatively large compared with the differences among treatment means. Dehusked ear weight is a yield component influenced by successful ear formation, kernel development, grain filling, and the plant's capacity to allocate assimilates to reproductive organs. Although organic amendments can improve soil conditions and support plant growth, these improvements do not necessarily result in a significant increase in ear weight within a single growing season.

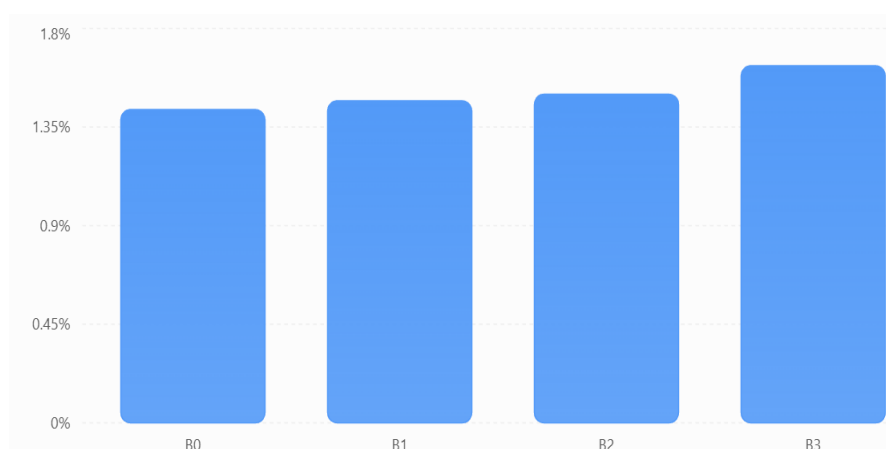
The tendency toward higher ear weights in B2 and B3 may be biologically associated with the potential of filter cake to supply organic matter and nutrients. Setiaji *et al.* (2023) investigated sugarcane filter cake-based fertilizers in sweet maize and found that several filter cake-based formulations could improve plant agronomic characteristics and nutrient-use efficiency. These findings support the potential use of filter cake to promote maize growth, but they do not establish that every filter cake application rate will significantly increase ear weight. The response remains dependent on fertilizer formulation, application rate, soil conditions, and the growing environment.

More direct comparative evidence was reported by Khatizah *et al.* (2025), who evaluated combinations of filter cake and NPK fertilizer in sweet maize. Their study reported a dehusked ear weight of 4.28 kg/plot for one of the treatment combinations that performed best for this parameter, while other treatment combinations produced different responses. This value falls within a comparable range to that observed in the present study. However, because Khatizah *et al.* used alluvial soil and combinations of filter cake with NPK fertilizer, whereas the present study was conducted on Inceptisol soil using *Trichoderma*-enriched filter cake, the comparison demonstrates agronomic relevance rather than equivalent responses between the two studies.

Soil organic C content

1. Soil C-organic content after treatment (%)

The analysis results indicate that the application of filter cake enriched with *Trichoderma* sp. had a significant effect on soil organic carbon content following the treatment. Organic carbon levels were 1.43% for B0, 1.47% for B1, 1.50% for B2, and 1.63% for B3. The highest value was observed in treatment B3 (3.375 kg of filter cake per plot enriched with 2 g of *Trichoderma* sp.), while the lowest value was found in B0, which received neither filter cake nor *Trichoderma* sp. (Figure 1).



Post-hoc test notation: B0 = c; B1 = bc; B2 = b; B3 = a. Identical letters indicate no significant difference based on the LSD test at the 5% level.

Figure 1: Histogram of soil organic C content (%) following treatment with *Trichoderma*-enriched filter cake.

Compared with B0, soil organic carbon (SOC) content increased by 0.04 percentage points (approximately 2.80%) in B1, 0.07 percentage points (4.90%) in B2, and 0.20 percentage points (13.99%) in B3. This pattern indicates a tendency for SOC content to increase with increasing filter cake application rates. This response is agronomically plausible because filter cake is a sugar industry residue containing organic matter and carbon; therefore, its incorporation into the soil can increase organic carbon inputs.

These findings are consistent with Magaña-Aquino et al. (2026), who reported significant differences in soil organic carbon and organic matter contents following filter cake application to sugarcane-growing soils. Similarly, Manyanga et al. (2026) reported significant differences in soil organic carbon content following the application of a mixture of sugarcane filter cake and vermiculite to sandy soil. Although the soil types, cropping systems, and organic amendment formulations differed from those in the present study, both studies support the explanation that the addition of filter cake-based materials can influence soil organic carbon content.

Mechanistically, the increase in SOC content under higher filter cake application rates may be attributed to

greater carbon inputs from the applied organic material. Some of this material may undergo microbial decomposition, while another fraction may remain in the soil as organic matter during the observation period. *Trichoderma* sp. may contribute to organic matter decomposition through its enzymatic activity. However, the present study cannot distinguish the contribution of *Trichoderma* from that of filter cake because the *Trichoderma* application rate was constant across B1, B2, and B3 at 2 g/plot. Therefore, the results are more appropriately interpreted as the effect of the combined application of filter cake and *Trichoderma* sp., with the observed tendency toward increased SOC content primarily associated with increasing filter cake application rates under a constant *Trichoderma* application rate.

2. Soil Organic Carbon Dynamics

The soil organic C content prior to treatment was 0.38%, indicating that the soil initially had a low organic carbon content. Following treatment, the soil organic C content increased across all treatments, reaching 1.43% for B0, 1.47% for B1, 1.50% for B2, and 1.63% for B3. Compared to initial conditions, these values represent increases of 1.05, 1.09, 1.12, and 1.25 percentage points, respectively. In relative terms, the increase ranged from 276.32% for B0 to 328.95% for B3 (Table 7).

Table 7: Dynamics of soil organic C content.

Condition/treatment	C-organic (%)	Increase from baseline (percentage points)	Relative increase from baseline
Before treatment	0.38	—	—
After treatment:			
B0 (control)	1.43	1.05	276.32%
B1	1.47	1.09	286.84%
B2	1.50	1.12	294.74%
B3	1.63	1.25	328.95%

Note: The relative increase is calculated using the formula: $((C_{\text{final}} - C_{\text{initial}}) / C_{\text{initial}}) \times 100\%$. This figure represents a numerical comparison relative to the initial condition, rather than the result of a significance test comparing pre- and post-treatment values.

The increase in soil organic carbon (SOC) content across all treatments indicates a change in soil organic carbon status during the experimental period. The highest final SOC content was recorded in B3, which received 3.375 kg of filter cake/plot enriched with 2 g of *Trichoderma* sp., reaching 1.63%. This value was 0.20 percentage points, or approximately 13.99%, higher than that of B0. This pattern suggests a tendency for higher filter cake application rates to be associated with greater soil organic carbon content.

Scientifically, this pattern can be explained by the addition of organic matter contained in filter cake. Filter cake is a residue from sugarcane processing that can be utilized as a fertilizer or soil amendment. Its application introduces organic carbon into the soil, some of which may undergo decomposition, while another fraction may remain as soil organic matter. In a study on sweet maize, Setiaji et al. (2023) reported that sugarcane filter cake-

based fertilizers could improve several soil quality indicators, including organic matter content under certain fertilizer formulations. These findings support the possibility that filter cake contributed to the increase in soil organic carbon observed in the present study.

Manyanga et al. (2026) also investigated the application of a mixture of sugarcane filter cake and vermiculite in maize cultivation on sandy soil, evaluating several soil chemical and physical properties. Their study provides a relevant comparison regarding the use of filter cake as a soil amendment. Nevertheless, the responses observed in that study cannot be directly equated with those of the present experiment because the soil types, amendment compositions, and cropping conditions differed.

An important consideration is that B0 also exhibited a final SOC content of 1.43%, substantially higher than the initial value of 0.38%, despite receiving neither filter

cake nor *Trichoderma*. Therefore, the increase from the initial value cannot be attributed entirely to the treatments. This change may also have been influenced by soil carbon dynamics during the experimental period, environmental conditions, land management practices, or variability in soil sampling and laboratory analysis. Establishing the contribution of the treatments requires appropriate statistical comparisons, together with information on sampling times and the consistency of the analytical methods used.

Overall, the results indicate that post-treatment SOC content ranged from 1.43% to 1.63%, compared with the initial value of 0.38%. B3 produced the highest final SOC content, whereas B0 had the lowest value among the treatments. If the analysis of variance and subsequent multiple-comparison tests demonstrate significant differences among treatments, B3 may be identified as the treatment with the highest SOC content statistically, in accordance with the test results. However, increases relative to the initial soil condition should be reported as descriptive changes rather than as evidence that each treatment differed significantly from the initial value.

CONCLUSION

The application of filter cake enriched with *Trichoderma* sp. resulted in varied responses regarding sweet corn growth, yield, and soil organic-C content. The treatments significantly affected stem diameter, weight of husked cobs per plot, and soil organic-C content, but did not significantly affect the weight of husked cobs per sample or the weight of husked-removed cobs (whether per sample or per plot). Numerically, treatment B3 (3.375 kg filter cake + 2 g *Trichoderma* sp. per plot) yielded a stem diameter of 20.36 mm, a husked cob weight per plot of 6.31 kg, and the highest soil organic-C content at 1.63%. Thus, B3 demonstrated the best numerical response across several parameters, although it did not differ significantly from B2 regarding stem diameter and husked cob weight per plot. Increasing the filter cake dosage while keeping the *Trichoderma* dosage constant tended to improve several growth, yield, and soil organic-C parameters. However, since the *Trichoderma* dosage remained the same across treatments B1 through B3, the effects of the individual components could not be independently distinguished.

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