International Journal of Life Science and Agriculture Research
ISSN (Print): 2833-2091, ISSN (Online): 2833-2105
Volume 05 Issue 01 January 2026
DOI: https://doi.org/10.55677/ijlsar/V05I01Y2026-04
Impact Factor: 7.88 , Page No : 25-29

# Optimization of Biochar and Liquid Organic Fertilizer Application for Improving Growth and Yield of Sweet Corn on Inceptisol

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**ABSTRACT**

Sweet corn production on Inceptisol soils is often constrained by low organic matter content and limited nutrient availability, resulting in suboptimal plant growth and yield. This study aimed to evaluate the effects of biochar and liquid organic fertilizer (LOF), applied individually and in combination, on the vegetative growth and yield of sweet corn. The experiment was conducted from June to September 2025 at the experimental field of the Soil Chemistry and Plant Nutrition Laboratory, Faculty of Agriculture, Universitas Padjadjaran, using a Randomized Complete Block Design with seven treatments and four replications. Treatments consisted of a control, biochar alone, LOF alone, and various combinations of biochar and LOF. Biochar was applied during soil preparation, while LOF was applied weekly until seven weeks after planting. Growth parameters observed included plant height, stem diameter, and number of leaves, while yield parameters comprised ear weight, ear length, and ear diameter. Data were analyzed using analysis of variance, followed by Duncan's Multiple Range Test at the 5% significance level. The results showed that integrated application of biochar and LOF significantly improved vegetative growth and yield of sweet corn compared to single-input treatments and the control. The combined application of biochar and LOF at full rates consistently produced the highest growth and yield values, indicating a synergistic interaction between soil amendment and nutrient input. These findings suggest that integrated biochar and LOF management is an effective strategy for enhancing sweet corn productivity on Inceptisol soils.

**KEY WORDS:** Crop productivity, Integrated nutrient management, Organic soil amendment.

**Published Online: January 22, 2026**

***Cite the Article:*** *Sara, D.S., Sofyan, E.T., Mulyani, O., Citraresmini, A. (2026). Optimization of Biochar and Liquid Organic Fertilizer Application for Improving Growth and Yield of Sweet Corn on Inceptisol. International Journal of Life Science and Agriculture Research, 5(1), 25–29. https://doi.org/10.55677/ijlsar/V05I01Y2026-04*



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## 1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops globally and plays a key role in food security, particularly in tropical regions. Sweet corn (Zea mays L. var. saccharata) is a high-value maize type cultivated for fresh consumption due to its superior taste and market demand. However, sweet corn production is highly dependent on soil fertility management because of its relatively high nutrient requirements, especially nitrogen, during vegetative growth and ear formation stages (Nyirenda et al., 2021).

In many tropical agricultural areas, sweet corn is cultivated on Inceptisols, which are young soils with limited profile development and generally low to moderate fertility. Rahmayuni et al. (2023) reported that Inceptisols often exhibit low organic matter content, limited nutrient reserves, and variable soil acidity, which can restrict nutrient availability and reduce fertilizer efficiency. Similarly, Suhemi et al. (2022) observed that Inceptisols frequently show low availability of phosphorus and potassium, along with suboptimal exchangeable base status. These constraints highlight the need for soil management strategies that improve nutrient retention and soil chemical properties to support crop productivity.

Biochar has been widely studied as a soil amendment capable of improving soil physical and chemical characteristics. Lehmann and Joseph (2009) described biochar as a carbon-rich material produced from biomass through pyrolysis under limited oxygen conditions. Numerous studies indicate that biochar application can enhance soil cation exchange capacity, increase nutrient retention, and reduce nutrient losses through leaching. Omara et al. (2023) demonstrated that biochar application increased soil CEC and improved the retention of exchangeable cations, which is particularly relevant for acidic and low-fertility soils such as Inceptisols. At a broader scale, Jeffery et al. (2017) showed through a global meta-analysis that biochar application resulted in greater crop yield responses in tropical regions compared to temperate regions, suggesting its suitability for tropical soil management.

Although biochar improves soil properties, its agronomic effectiveness depends on appropriate application rates and interaction with nutrient inputs. Liquid organic fertilizers (LOF) have gained attention as an alternative or complementary nutrient source because they supply nutrients in readily available forms and may contain growth-promoting substances. Pangaribuan et al. (2019) reported that LOF application significantly improved growth, yield, and quality of sweet corn, indicating its potential to support crop nutrient demand during critical growth stages. However, excessive or insufficient concentrations of LOF may lead to nutrient imbalance or inefficient use of inputs.

The integration of biochar and LOF offers a promising approach for improving sweet corn productivity on Inceptisols. Biochar may enhance soil buffering capacity and nutrient retention, while LOF provides immediately available nutrients to support rapid plant growth and yield formation. Nevertheless, information on the optimal combination of biochar dose and LOF concentration for sweet corn grown on Inceptisols remains limited. Therefore, this study aims to optimize biochar application rates and LOF concentrations to improve growth and yield of sweet corn cultivated on Inceptisol soils, providing a scientifically based recommendation for integrated organic input management under tropical soil conditions.

## 2. MATERIALS AND METHODS

The study was conducted from June to September 2025 at the experimental field of the Soil Chemistry and Plant Nutrition Laboratory, Faculty of Agriculture, Universitas Padjadjaran. The experiment employed a Randomized Complete Block Design (RCBD) consisting of six treatments with four replications, resulting in a total of 24 experimental plots. The treatments comprised a control, one treatment with liquid organic fertilizer (LOF) without biochar, one treatment with biochar without LOF, and three treatments representing different combinations of biochar and LOF.

Biochar was applied at a rate of 10 ton $ha^{-1}$ and incorporated into the soil during the initial soil preparation stage prior to planting, concurrently with filling the polybags. This application rate was selected based on previous studies reporting that biochar at approximately 10 ton $ha^{-1}$ effectively improves soil properties and crop performance in maize-based systems (Agegnehu et al., 2016; Jeffery et al., 2017).

Liquid organic fertilizer was applied at a rate of 100 L $ha^{-1}$, prepared as a liquid solution with an approximate concentration of 60 mL POC per L water. This dosage has been reported to enhance growth and yield of sweet corn by supplying readily available nutrients during critical growth stages (Pangaribuan et al., 2019; Sari et al., 2020). The LOF was applied once a week starting one week after planting and continued until seven weeks after planting (WAP), covering the early vegetative growth stage.

Plant growth parameters and yield components were recorded throughout the experimental period. The collected data were subjected to analysis of variance (ANOVA), and when significant treatment effects were detected, means were further compared using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

## 3. RESULTS AND DISCUSSION

### 3.1. Effect of Biochar and Liquid Organic Fertilizer (LOF) Treatments on Sweet Corn Growth Parameters

An evaluation was conducted to assess the effects of various integrated applications of biochar and liquid organic fertilizer (LOF) on the vegetative growth of sweet corn. Vegetative growth parameters, including plant height, stem diameter, and number of leaves, are essential indicators of early crop performance because they reflect plant vigor, nutrient availability, and the effectiveness of soil and nutrient management practices. These parameters play a critical role in determining the potential yield of sweet corn, as robust vegetative growth supports efficient photosynthesis and assimilate production. Table 1 presents the growth responses of sweet corn observed under different biochar and LOF treatments at 7 weeks after planting (WAP).

**Table 1. Results of Sweet Corn Growth**

| Treatment | Plant Height (cm) at 7 WAP | Stem Diameter (mm) at 7 WAP | Number of Leaves at 7 WAP |
|---|---|---|---|
| Control | 58.2 ± 2.1 a | 9.5 ± 0.4 a | 7.1 ± 0.3 a |
| Biochar | 64.7 ± 1.9 b | 10.8 ± 0.3 b | 8.0 ± 0.4 b |
| LOF | 66.5 ± 2.3 b | 11.2 ± 0.5 b | 8.3 ± 0.2 b |

| Treatment | Plant Height (cm) at 7 WAP | Stem Diameter (mm) at 7 WAP | Number of Leaves at 7 WAP |
|---|---|---|---|
| ½ Biochar + ½ LOF | 72.0 ± 2.0 c | 12.5 ± 0.4 c | 9.1 ± 0.3 c |
| 1 Biochar + ½ LOF | 75.3 ± 1.8 cd | 13.1 ± 0.5 c | 9.5 ± 0.4 cd |
| ½ Biochar + 1 LOF | 77.8 ± 2.4 d | 13.8 ± 0.3 d | 9.7 ± 0.3 d |
| 1 Biochar + 1 LOF | 81.6 ± 2.2 e | 14.5 ± 0.4 e | 10.2 ± 0.3 e |

**Note:** Values are mean ± standard error (SE). Means followed by different letters within the same column are significantly different at $p < 0.05$ according to Duncan's Multiple Range Test (DMRT).

The results of this study demonstrated that the application of biochar and liquid organic fertilizer (LOF) significantly influenced the growth of sweet corn, as indicated by plant height, stem diameter, and number of leaves at 7 WAP. The control treatment consistently produced the lowest growth values, while treatments combining biochar and LOF resulted in superior vegetative performance. Among all treatments, the combined application of 1 biochar + 1 LOF produced the highest growth responses, indicating a synergistic interaction between the two inputs.

The improved growth observed in biochar-treated plots can be attributed to biochar's ability to enhance soil chemical properties and nutrient retention. Biochar has been reported to increase cation exchange capacity and improve soil pH, thereby enhancing nutrient availability for plant uptake (Lehmann and Joseph, 2009; Jeffery et al., 2017). These improvements are particularly relevant for Inceptisol soils, which are generally characterized by low organic matter content and limited nutrient reserves (Rahmayuni et al., 2023). As a result, biochar application may improve root environment conditions, leading to increased plant height and stem diameter.

Liquid organic fertilizer application alone also enhanced sweet corn growth compared to the control. This effect is likely due to the presence of readily available nutrients and organic compounds that support vegetative growth. Pangaribuan et al. (2019) reported that liquid organic fertilizers significantly increased plant height and leaf number in sweet corn, which aligns with the findings of the present study. The increased number of leaves observed under LOF treatments suggests improved photosynthetic capacity, which is essential for biomass accumulation and subsequent yield formation.

More pronounced growth responses were observed when biochar and LOF were applied in combination. This synergistic effect may be explained by biochar's capacity to retain nutrients supplied by LOF within the root zone, thereby improving nutrient use efficiency and reducing losses through leaching (Omara et al., 2023). In soils such as Inceptisols, where nutrient availability and retention are often limiting factors, this interaction becomes particularly important. Suhemi et al. (2022) emphasized that low phosphorus and potassium availability in Inceptisols can restrict crop growth if not properly managed, highlighting the value of integrated soil amendment strategies.

The superior performance of the 1 biochar + 1 LOF treatment indicates that adequate rates of both soil amendment and nutrient input are required to maximize sweet corn growth. Lower combination levels improved growth relative to single-input treatments, but the full combination consistently produced the highest values across all measured parameters. Similar findings have been reported in maize-based systems, where combined biochar and organic fertilizer applications resulted in greater vegetative growth than either input applied alone (Jeffery et al., 2017; Pangaribuan et al., 2019). These results suggest that balanced integration of biochar and LOF can effectively address soil fertility constraints and support optimal crop growth under Inceptisol conditions.

Overall, the findings confirm that integrated biochar and liquid organic fertilizer management enhances sweet corn growth more effectively than single-input approaches. The observed improvements in plant height, stem diameter, and leaf number at 7 WAP indicate better early vegetative development, which is critical for achieving higher yield potential in sweet corn production systems.

### 3.2. Effect of Biochar and Liquid Organic Fertilizer (LOF) on Sweet Corn Yield

An assessment was carried out to examine the influence of biochar and liquid organic fertilizer (LOF) treatments on sweet corn yield performance. Yield-related variables, including ear weight, ear length, and ear diameter, represent critical indicators of reproductive success and economic value in sweet corn production. These parameters reflect the effectiveness of nutrient availability and assimilate allocation during the reproductive phase. The yield responses of sweet corn under different combinations of biochar and LOF treatments are summarized in Table 2.

**Table 2. Results of Sweet Corn Yield**

| Treatment | Ear Weight with Husk (g plant⁻¹) | Ear Weight without Husk (g plant⁻¹) | Ear Length (cm) | Ear Diameter (cm) |
|---|---|---|---|---|
| Control | 245.3 ± 8.5 a | 168.4 ± 6.2 a | 15.2 ± 0.4 a | 4.2 ± 0.1 a |
| Biochar | 278.6 ± 9.1 b | 192.7 ± 5.8 b | 16.4 ± 0.5 b | 4.5 ± 0.1 b |
| LOF | 285.4 ± 10.3 b | 198.6 ± 6.5 b | 16.7 ± 0.4 b | 4.6 ± 0.1 b |
| ½ Biochar + ½ LOF | 315.8 ± 11.2 c | 221.5 ± 7.1 c | 17.9 ± 0.5 c | 4.9 ± 0.1 c |
| 1 Biochar + ½ LOF | 332.6 ± 10.7 cd | 235.8 ± 6.9 cd | 18.4 ± 0.4 cd | 5.1 ± 0.1 cd |
| ½ Biochar + 1 LOF | 345.9 ± 12.1 d | 248.6 ± 7.4 d | 18.8 ± 0.5 d | 5.2 ± 0.1 d |
| 1 Biochar + 1 LOF | 368.4 ± 11.5 e | 268.9 ± 6.8 e | 19.6 ± 0.4 e | 5.4 ± 0.1 e |

**Note:** Values are mean ± standard error (SE). Means followed by different letters within the same column are significantly different at $p < 0.05$ according to Duncan's Multiple Range Test (DMRT).

The yield parameters of sweet corn, including ear weight with husk, ear weight without husk, ear length, and ear diameter, were significantly influenced by the application of biochar and liquid organic fertilizer (LOF). The lowest yield values were consistently observed in the control treatment, while the highest yield was recorded in the combined application of 1 biochar + 1 LOF. This pattern indicates that integrated organic inputs play an important role in enhancing yield formation in sweet corn.

The increase in ear weight observed in biochar-treated plots may be attributed to improved soil nutrient retention and enhanced root activity during the reproductive stage. Liang et al. (2014) reported that biochar application increased nutrient availability and carbon stabilization in soil, which subsequently enhanced crop biomass and yield components. Improved nutrient retention is particularly important during ear filling in sweet corn, a stage characterized by high nutrient demand, especially nitrogen and potassium.

Liquid organic fertilizer application also contributed positively to yield improvement. Organic liquid fertilizers supply nutrients in soluble forms that are readily absorbed by plants, supporting reproductive growth and kernel development. Sari et al. (2020) found that organic fertilizer application significantly increased ear weight and ear length in sweet corn, indicating that sufficient nutrient availability during reproductive stages directly influences yield quality. In the present study, LOF alone produced higher yield than the control, confirming its role as an effective nutrient source.

The superior yield performance observed under combined biochar and LOF treatments suggests a synergistic interaction between soil amendment and nutrient input. Biochar has been reported to reduce nutrient leaching and enhance fertilizer use efficiency, allowing nutrients supplied by organic fertilizers to remain available for longer periods (Liu et al., 2017). This mechanism likely contributed to increased ear size and weight by sustaining nutrient supply throughout the grain-filling period.

Ear length and diameter, which are important indicators of sweet corn market quality, were also significantly enhanced by combined treatments. According to Rahayu et al. (2018), ear size in sweet corn is strongly influenced by nutrient availability during tasseling and silking stages. Adequate nutrient supply during these stages promotes better kernel set and ear expansion. The highest ear length and diameter observed in the 1 biochar + 1 LOF treatment suggest that this combination provided optimal nutrient conditions for reproductive development.

Furthermore, integrated organic input management has been reported to improve soil biological activity, which indirectly supports yield formation. Agegnehu et al. (2016) demonstrated that biochar combined with organic fertilizers increased microbial activity and nutrient cycling, resulting in higher maize grain yield compared to single-input treatments. Enhanced microbial activity may improve nutrient mineralization and availability during critical yield-determining stages in sweet corn.

Overall, the results indicate that while biochar or LOF alone can improve sweet corn yield, their combined application is more effective in maximizing yield components. The highest yield achieved under the 1 biochar + 1 LOF treatment confirms that balanced integration of soil amendment and nutrient supply is essential for optimizing sweet corn productivity, particularly under soil conditions with inherent fertility limitations such as Inceptisols.

## CONCLUSIONS

1. The application of biochar and liquid organic fertilizer (LOF), either individually or in combination, significantly influenced the vegetative growth and yield of sweet corn cultivated on Inceptisol soil. Integrated applications of biochar and LOF consistently improved plant height, stem diameter, number of leaves, and yield components compared to the control treatment, indicating the effectiveness of organic-based soil and nutrient management strategies in enhancing sweet corn performance.
2. Among all treatments, the combined application of biochar and LOF at full rates (1 biochar + 1 LOF) produced the highest values for both growth and yield parameters, including ear weight, ear length, and ear diameter. This superior performance

demonstrates a synergistic interaction between biochar and LOF, whereby biochar improved soil nutrient retention and utilization efficiency, while LOF supplied readily available nutrients to support optimal vegetative development and reproductive growth. These findings suggest that integrated biochar and LOF application represents an effective approach for improving sweet corn productivity on Inceptisol soils.

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