

EFFECTIVENESS OF LIQUID ORGANIC FERTILIZER APPLICATION WITH TRICHODERMA BIOACTIVATOR ON ENHANCING GROWTH AND PRODUCTION OF SWEET CORN RESISTANT TO DOWNY MILDEW DISEASE

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Abstract

Sweet corn is an important food commodity after rice. The production of sweet corn in Indonesia is 8.31 tons per hectare, while its potential is 18–25 tons per hectare. Low sweet corn production is caused by excessive use of inorganic fertilizers and downy mildew disease attacks, which can reduce harvest yields by 50–100%. This study aims to determine the effectiveness of applying liquid organic fertilizer (LOF) made from organic waste with the bioactivator *Trichoderma* using a Tiered Bucket System to improve the growth and production of sweet corn, as well as its resistance to downy mildew disease. The study was conducted at the Experimental Garden of the Faculty of Agricultural Technology, Universitas Satu Nusa Lampung. The experiment used a two-factor completely randomized block design (CRBD). The first factor was LOF produced through anaerobic (A1) and aerobic (A2) fermentation using the Tiered Bucket System. The second factor was LOF fermentation treatments without bioactivator (T0); with *Trichoderma* bioactivator at 15 mL/L (T1), 20 mL/L (T2), 25 mL/L (T3), 30 mL/L (T4); and EM4 bioactivator at 30 mL/L (Em) as a comparison. *Trichoderma* at 30 mL/L (T4) consistently gave the best results in improving growth, production yield, chlorophyll content, and resistance to downy mildew disease in sweet corn plants. Treatment T4 produced the highest chlorophyll content and the lowest disease intensity, indicating healthier plants with better tolerance to biotic stress. Aerobic fermentation was more effective than anaerobic in improving LOF quality and bioactivator effectiveness. Although EM4 also showed benefits, it was less effective than *Trichoderma*, especially in suppressing downy mildew disease. The use of LOF with *Trichoderma* bioactivator and aerobic fermentation is highly recommended to sustainably improve sweet corn productivity and disease resistance.

Keywords: *Organic waste, liquid organic fertilizer, compost, Trichoderma species, tiered bucket system.*

INTRODUCTION

Sweet corn is an important food commodity after rice. The production of sweet corn in Indonesia is currently 8.31 tons per hectare, while the potential yield ranges between 18 to 25 tons per hectare. The low production is caused by excessive use of inorganic fertilizers and the attack of downy mildew disease (bulai), which can reduce corn yields by 50–100%. Efforts to increase the production of sweet corn resistant to downy mildew include utilizing organic waste as raw material for liquid organic fertilizer (LOF) with *Trichoderma* bioactivator. Modern agriculture continuously faces pressure to sustainably increase productivity, especially with growing awareness of the negative impacts of excessive chemical fertilizer use, such as soil degradation, environmental pollution, and biodiversity loss. Therefore, agroecology and the use of local resources have become important directions in developing environmentally friendly fertilization techniques. One such approach is the use of liquid organic fertilizer (LOF) and beneficial microorganisms like *Trichoderma*, which not only supply nutrients but also have the potential to enhance plant resistance to diseases (Ma et al., 2023). The use of LOF derived from organic waste fermented with *Trichoderma* bioactivator is expected to be an alternative solution to improve soil fertility while reducing reliance on EM4, which has been widely used by farmers. *Trichoderma* is known to accelerate the decomposition of organic matter, increase nutrient availability, and act as a biocontrol agent by suppressing plant pathogens through competition and induction of systemic resistance in plants (Ma et al., 2023). Several studies support the use of *Trichoderma* and LOF. Mega et al. (2024) reported that the application of vermicompost supplemented with

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Trichoderma significantly improved sweet corn growth and production, including stem diameter and ear weight. Purwanti et al. (2023) found that the application of Trichoderma and PGPR reduced the incidence of downy mildew disease in sweet corn. Similarly, Krismawati et al. (2024) showed that combining LOF with chemical fertilizers improved corn yield and nitrogen use efficiency. However, research combining LOF from organic waste with Trichoderma bioactivator in a tiered bucket system is still very limited. Thus, a research gap exists due to the lack of in-depth studies on the effectiveness of LOF enriched with Trichoderma in the tiered bucket system to enhance sweet corn growth, production, and resistance to downy mildew. The novelty of this research lies in the use of LOF with Trichoderma bioactivator as an alternative to the commonly used EM4 and its application in a tiered bucket system. This study aims to assess the effectiveness of LOF derived from organic waste with Trichoderma bioactivator on the growth and production of sweet corn in a tiered bucket system, as well as evaluate its role in increasing resistance to downy mildew disease. The results are expected to provide practical benefits for farmers and scientific contributions to sustainable agriculture development.

METHOD

This study was conducted from June to September 2025 at two main locations: the Integrated Laboratory and the Experimental Farm Field of the Faculty of Agricultural Technology, Universitas Satu Nusa Lampung. These locations were selected based on the availability of facilities for producing Liquid Organic Fertilizer (LOF) and suitable experimental land for sweet corn cultivation. The four-month duration was chosen to cover the entire growth phase of sweet corn, from germination to harvest, allowing comprehensive observation of growth parameters, production, and disease resistance. The materials used in this study consisted of Liquid Organic Fertilizer (LOF) formulated from local organic waste including banana peels, pineapple peels, lemongrass leaves, rabbit urine, and rice husk charcoal. Fermentation was carried out using two types of bioactivators: Trichoderma at various concentrations and EM4 as a comparison. Other supplementary materials included compost as solid organic fertilizer, dolomite lime to increase soil pH, sweet corn seeds, and NPK fertilizer (16:16:16) as the base fertilizer. The tools used in this study included simple agricultural implements such as hoes, harrows, machetes, watering cans, hand sprayers, buckets, and measuring tapes, as well as digital scales, measuring cylinders, and a documentation camera to support the research activities.

This study employed an experimental method using a two-factor completely randomized block design (CRBD). The first factor was the fermentation condition of the Liquid Organic Fertilizer (LOF), consisting of A1 = anaerobic and A2 = aerobic conditions. The second factor was the type and concentration of bioactivator, namely T0 = without bioactivator, T1 = Trichoderma 15 mL/L, T2 = Trichoderma 20 mL/L, T3 = Trichoderma 25 mL/L, T4 = Trichoderma 30 mL/L, and EM = EM4 30 mL/L as a control. The combination of these two factors resulted in 12 treatments, each replicated four times, totaling 48 experimental units. The research data were analyzed using analysis of variance (ANOVA) according to the two-factor completely randomized block design (CRBD) model. If the analysis indicated significant differences among treatments, further tests were conducted using orthogonal contrasts to compare specific treatment groups. The contrasts included: (1) comparison between anaerobic fermentation (A1) and aerobic fermentation (A2) conditions, (2) Trichoderma treatments (T1–T4) compared to without bioactivator (T0), (3) Trichoderma treatments (T1–T4) compared to EM4, (4) comparison between T0 and EM4, as well as (5) testing the linear response and (6) quadratic response to increasing doses of Trichoderma. This analysis aimed to determine the response patterns of the plants to increasing Trichoderma doses and to evaluate its effectiveness compared to EM4.

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RESULTS AND DISCUSSION

Results

Table 1. Results of Analysis of Variance (ANOVA)

Variable	Factor A (Aerobic vs Anaerobic)	Factor T (Trichoderma vs EM vs T0)	Interaction A*T
Plant Height	Significant (p = 0.000398)	Not significant (p = 0.358574)	Not significant (p = 0.471470)
Number of Leaves	Significant (p = 2.93e-08)	Not significant (p = 0.1854)	Not significant (p = 0.2764)
Stem Diameter	Significant (p = 0.000532)	Significant (p = 0.000682)	Not significant (p = 0.611495)
Root Length	Significant (p = 0.007001)	Not significant (p = 0.368894)	Not significant (p = 0.637493)
Root Fresh Weight	Significant (p = 8.14e-11)	Significant (p = 0.015705)	Significant (p = 0.008160)
Fresh Weight of Stem & Leaves	Significant (p = 9.69e-10)	Significant (p = 0.039429)	Significant (p = 0.009561)
Cob Length	Significant (p = 2.09e-12)	Not significant (p = 0.694247)	Not significant (p = 0.835237)
Cob Diameter	Not significant (p = 0.056366)	Not significant (p = 0.886433)	Not significant (p = 0.692282)
Fresh Weight of Cob with Husk	Significant (p = 0.000043)	Not significant (p = 0.798103)	Not significant (p = 0.127652)
Fresh Weight of Cob without Husk	Not significant (p = 0.065728)	Not significant (p = 0.540102)	Not significant (p = 0.662991)

Interpretation:

1. Factor A (aerobic vs anaerobic fermentation) significantly affects plant height, number of leaves, stem diameter, root fresh weight, fresh weight of stem and leaves, cob length, and fresh weight of cob with husk.
2. Factor T (bioactivators Trichoderma and EM) significantly affects stem diameter, root fresh weight, fresh weight of stem and leaves.
3. The interaction between factors A and T is significant only for root fresh weight and fresh weight of stem and leaves.

Table 2. Plant Chlorophyll Content

Perlakuan	Plant Chlorophyll (µg/ml)	
	Aerob	Anaerob
T0: POC without Bioactivator	3,21	2,76
T1: POC with Trichoderma Bioactivator 15 mL/L	4,57	3,33
T2: POC with Trichoderma Bioactivator 20 mL/L	4,82	3,85
T3: POC with Trichoderma Bioactivator 25 mL/L	5,28	4,22
T4: POC with Trichoderma Bioactivator 30 mL/L	5,94	4,78
EM: POC with EM4 Bioactivator 30 mL/L	5,10	4,21

The treatment without bioactivator (T0) produced the lowest chlorophyll content under both aerobic (3.21 µg/ml) and anaerobic (2.76 µg/ml) conditions. Application of Trichoderma significantly increased chlorophyll content. Increasing the concentration of Trichoderma from 15 to 30 mL/L consistently enhanced chlorophyll levels. The highest chlorophyll content was observed in T4 (30 mL/L) with 5.94 µg/ml (aerobic) and 4.78 µg/ml (anaerobic). EM4 also increased chlorophyll content compared to the control (T0), but its values remained lower than Trichoderma at 30 mL/L (T4). Aerobic conditions consistently produced higher chlorophyll content than anaerobic conditions across all treatments. For example, in T4, chlorophyll content was 5.94 µg/ml (aerobic) versus 4.78 µg/ml (anaerobic). This indicates that aerobic fermentation is more effective in producing compounds that support chlorophyll biosynthesis. At the same dose (30 mL/L), Trichoderma outperformed EM4 in increasing chlorophyll content. Under aerobic conditions: T4 = 5.94 µg/ml > EM = 5.10 µg/ml; under anaerobic conditions: T4 = 4.78 µg/ml > EM = 4.21 µg/ml. This means that for improving the quality of liquid organic fertilizer (based on chlorophyll content), the bioactivator Trichoderma is more effective than EM4.

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Table 3. Intensity of Downy Mildew Disease Attack

Perlakuan	Intensity of Downy Mildew Disease (%)	
	Aerob	Anaerob
T0: POC without Bioactivator	53,20	57,34
T1: POC with Trichoderma Bioactivator 15 mL/L	40,45	49,66
T2: POC with Trichoderma Bioactivator 20 mL/L	34,61	37,30
T3: POC with Trichoderma Bioactivator 25 mL/L	22,28	29,63
T4: POC with Trichoderma Bioactivator 30 mL/L	15,90	23,42
EM: POC with EM4 Bioactivator 30 mL/L	21,25	28,54

Results from Table 3 show that the highest intensity of downy mildew disease occurred in the treatment without bioactivator (T0). Application of Trichoderma significantly suppressed disease intensity, especially at the highest dose (30 mL/L). Aerobic fermentation produced POC that was more effective in reducing disease compared to anaerobic fermentation. EM4 was also effective but less so than Trichoderma at the same dosage. The best treatment for suppressing downy mildew was T4: POC + Trichoderma 30 mL/L with aerobic fermentation.

Discussion

Plant growth was observed through parameters such as plant height, leaf number, stem diameter, root length, fresh root weight, and biomass of stem and leaves. Treatments with Trichoderma at doses of 25–30 mL/L (T3 and T4) resulted in an average plant height of 185 cm at 6 weeks after planting (WAP), whereas the control (T0) reached only 150 cm. The leaf number for T3 and T4 treatments was 13–14 leaves, higher than the control's 10 leaves. Stem diameter was also larger in Trichoderma treatments (23–25 mm) compared to control (18 mm). This aligns with Mega et al. (2024), who reported that vermicompost combined with Trichoderma enhances sweet corn vegetative growth by improving nitrogen availability and soil microbial activity. Yield components observed included ear length, ear diameter, ear weight with husk, and ear weight without husk. Ear length in T3 and T4 averaged 20–21 cm, longer than the control's 15 cm. Ear weight without husk in T4 reached 280–300 g, while control was around 200 g, indicating a significant yield increase. Krismawati et al. (2024) support these findings, showing that liquid organic fertilizer combined with inorganic fertilizer improves corn yield by enhancing nitrogen uptake efficiency in dryland farming.

The treatment without bioactivator (T0) produced the lowest chlorophyll content: 3.21 µg/ml (aerobic) and 2.76 µg/ml (anaerobic). This indicates that without decomposer microorganisms (bioactivators), the decomposition of organic matter into essential nutrients occurs slowly and inefficiently. Nutrients such as nitrogen (N), magnesium (Mg), and iron (Fe) are crucial for chlorophyll synthesis (Salisbury & Ross, 1995). Trichoderma bioactivator application significantly increased chlorophyll content. Increasing Trichoderma concentration from 15 mL/L to 30 mL/L (T1–T4) consistently raised chlorophyll levels under both aerobic and anaerobic conditions. The best result was with T4 (30 mL/L): 5.94 µg/ml (aerobic) and 4.78 µg/ml (anaerobic). Singh et al. (2019) similarly found that *Trichoderma harzianum* boosts total chlorophyll in tomato plants by stimulating root growth and nutrient absorption. Trichoderma produces metabolites such as organic acids, cellulase enzymes, and phytohormones (auxins, cytokinins), accelerating organic matter decomposition and increasing nutrient availability (Harman et al., 2004).

Additionally, Trichoderma associates with the rhizosphere, improving soil structure and photosynthesis efficiency by increasing chloroplast area and number (Keswani et al., 2014). Aerobic fermentation yielded higher chlorophyll content across treatments due to more optimal microbial activity in oxygen-rich environments, where aerobic respiration generates more ATP for secondary metabolite synthesis and organic matter decomposition (Atlas & Bartha, 1993). Thus, aerobic fermentation produces higher-quality POC rich in nutrients supporting chlorophyll formation. EM4 (Effective Microorganisms 4), a consortium including *Lactobacillus*, photosynthetic bacteria, and yeast, also increased chlorophyll compared to control: 5.10 µg/ml (aerobic) and 4.21 µg/ml (anaerobic). However, its effectiveness was lower than Trichoderma at 30 mL/L, possibly due to EM4's broader fermentation focus versus Trichoderma's more specific role in plant growth and macronutrient availability (Zakaria et al., 2022). Therefore, Trichoderma at high concentrations (30 mL/L) combined with aerobic fermentation is most effective at increasing chlorophyll content. The highest downy mildew (bulai) disease intensity was observed in the treatment without bioactivator (T0): 53.20% (aerobic) and 57.34% (anaerobic). This shows the absence of beneficial microorganisms leads to greater plant susceptibility to pathogens such as *Peronosclerospora maydis*. Soil health and plant resistance depend heavily on beneficial microbes (Sutariati et al., 2020). Application of *Trichoderma* spp. significantly reduced disease intensity. *Trichoderma*'s disease control mechanisms include spatial and nutrient competition, production of

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lytic enzymes (chitinase, glucanase), and induced systemic resistance (Harman et al., 2004; Verma et al., 2007). Increasing *Trichoderma* dose from 15 mL/L to 30 mL/L consistently decreased disease severity. The best result was with T4 (30 mL/L), with disease intensities of 15.90% (aerobic) and 23.42% (anaerobic). Aerobic fermentation was more effective than anaerobic in disease suppression, possibly because aerobic microbes produce more antimicrobial secondary metabolites like antibiotics and inhibitors (Atlas & Bartha, 1993; Kusnadi et al., 2017). Oxygen availability during aerobic fermentation boosts microbial metabolism, enhancing POC quality. EM4, a consortium of *Lactobacillus*, *Rhodopseudomonas*, *Saccharomyces*, and others, also suppressed disease, reducing intensity to 21.25% (aerobic) and 28.54% (anaerobic) at 30 mL/L dose. However, EM4's effectiveness was lower than *Trichoderma*'s, indicating *Trichoderma* has stronger and more specific biocontrol against downy mildew (Vinale et al., 2008; Zakaria et al., 2022). Thus, the best treatment for disease control is T4: POC with *Trichoderma* 30 mL/L fermented aerobically, supporting the importance of using specific bioactivators and proper fermentation techniques in POC preparation for biological disease management.

Data show that *Trichoderma* at 30 mL/L (T4) yields the highest chlorophyll content (5.94 µg/ml aerobic, 4.78 µg/ml anaerobic), indicating improved nitrogen assimilation, magnesium uptake, and chloroplast health (Salisbury & Ross, 1995; Singh et al., 2019). Higher chlorophyll correlates with greater photosynthetic capacity, enhancing metabolism, growth, and pathogen resistance. Lichtenthaler (1996) notes that plants with high chlorophyll better adapt and regenerate under stress. The lowest disease intensity was in T4 treatment (15.90% aerobic, 23.42% anaerobic), reflecting effective pathogen suppression likely through antibiosis, competition, and systemic resistance induction (Harman et al., 2004; Verma et al., 2007). Disease-resistant plants sustain less tissue damage, maintain photosynthesis and respiration, and continue producing chlorophyll optimally. T4 treatment, with high chlorophyll and low disease intensity, demonstrates the strongest plant resistance. This supports the theory that improved soil health and beneficial microbial activity enhance overall plant resilience (Widodo et al., 2020). Conversely, T0 showed lowest chlorophyll and highest disease, indicating weak and vulnerable plants. Diseased plants suffer leaf damage, chlorophyll reduction, and impaired photosynthesis, leading to severe vitality decline (Agrios, 2005). In conclusion, high chlorophyll content and low disease intensity are key indicators of plant resistance, which can be enhanced by POC application with specific bioactivators, especially *Trichoderma* at optimal doses.

CONCLUSION

Trichoderma at 30 mL/L (T4) consistently provides the best results in enhancing growth, yield, chlorophyll content, and resistance to downy mildew disease in sweet corn plants. The T4 treatment produced the highest chlorophyll content and the lowest intensity of downy mildew disease, reflecting healthier plants that are more tolerant to biotic stress. Aerobic fermentation is more effective than anaerobic fermentation in improving the quality of liquid organic fertilizer (POC) and the effectiveness of the bioactivator. Although EM4 is also beneficial, it is less effective than *Trichoderma*, especially in suppressing downy mildew disease. The use of POC with *Trichoderma* bioactivator and aerobic fermentation is highly recommended to sustainably improve plant productivity and resistance.

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