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Effect of Aerated and Non-Aerated Compost Tea at Different Concentrations on Early Growth of Maize (*Zea mays L.*)

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Abstract*— Declining soil fertility caused by the continuous use of chemical fertilizers has encouraged the development of sustainable and environmentally friendly nutrient management strategies. Compost tea, a liquid extract derived from mature compost, has gained attention due to its potential to supply readily available nutrients and beneficial microorganisms. This study aimed to evaluate the compost tea production process and assess the effects of aerated compost tea (ACT) and non-aerated compost tea (NACT) at different application concentrations on the early growth of maize (Zea mays L.). The experiment was conducted under controlled conditions in November 2025 using maize as the test plant. Compost tea was prepared by extracting mature compost in water at a ratio of 1:5, with aeration applied for ACT and without aeration for NACT over a three-day fermentation period. Treatments consisted of ACT and NACT applied at concentrations of 30 ml and 60 ml, along with a control. Plant growth parameters, including plant height and root length, were observed during the early growth phase (2–7 days after planting). The results showed that compost tea application significantly affected maize growth during the early growth stage ($P < 0.05$). Aerated compost tea generally produced better growth responses than non-aerated compost tea, particularly at lower concentrations. The ACT treatment at 30 ml resulted in the highest plant height and root length, while higher concentrations, especially NACT at 60 ml, tended to suppress plant growth. These findings indicate that compost tea primarily functions as an early growth stimulant and that excessive application may reduce its effectiveness. In conclusion, aerated compost tea at low concentrations is more effective in promoting early maize growth than non-aerated compost tea. Proper optimization of compost tea concentration and application strategy is essential to maximize its benefits within sustainable agricultural systems.

***Keywords*—** *Compost tea; Aeration; Maize growth; Sustainable agriculture; Organic fertilizer*

I. INTRODUCTION

The decline in soil fertility due to reduced organic matter content has become one of the major problems in intensive agricultural systems. Continuous use of chemical fertilizers has been reported to cause soil quality degradation, reduce the activity of beneficial microorganisms, and disrupt the balance of soil ecosystems [1]. These conditions highlight the urgent need for alternative fertilizer innovations that are more environmentally friendly and sustainable to maintain long-term agricultural productivity, particularly during the early growth stages of crops such as maize, where seed vigor and initial nutrient availability strongly influence seedling establishment [8].

One potential alternative is compost tea, which is a liquid extract derived from high-quality compost and applied as a liquid fertilizer. The utilization of compost tea is known to increase the added value of compost while improving its efficiency for plant uptake [9]. Compost tea contains living microorganisms and dissolved nutrients that are readily absorbed by plants, making it potentially more effective in enhancing seed germination, early seedling growth, and overall plant health compared to solid compost [10].

In addition to serving as a nutrient source, compost tea has been reported to supply beneficial microorganisms capable of suppressing soil-borne pathogens through competition and the production of antimicrobial compounds [6]. The presence of bioactive compounds in compost tea, such as plant hormones, organic acids, humic substances, and natural antibiotics, contributes to improved seedling vigor and plant resistance against both biotic and abiotic stresses during the initial growth phase [7].

The compost tea production process generally involves soaking compost in water, either with or without aeration. Aeration aims to enhance the population of aerobic microorganisms that play an important role in improving soil fertility and nutrient availability, particularly in the rhizosphere during early root development [2]. Dissolved organic compounds in compost tea also support soil structure improvement and increase biological activity in the rhizosphere [7]. Periodic application of compost tea has been reported to enhance soil enzyme activity associated with nutrient uptake, ultimately leading to increased crop productivity [5]. Therefore, compost tea has strong potential as a supporting technology in sustainable agricultural systems.

II. MATERIAL AND METHODS

The research was conducted in November 2025 at the 3rd floor of the ISDB Building under controlled conditions using maize plants as the experimental material. The main materials used in this study included mature compost as a source of microorganisms and nutrients, clean water as the extraction medium, and maize seeds as the test plants. The equipment used consisted of fermentation containers (gallons), filter cloth, aerators for the aerated treatment, and other supporting tools.

The compost tea preparation process was carried out by extracting mature compost into water at a compost-to-water ratio of 1:5. The compost was wrapped in filter cloth and placed into a gallon containing clean water. For the aerated compost tea (ACT) treatment, the solution was fermented with continuous aeration for three days to enhance aerobic microbial activity. Meanwhile, the non-aerated compost tea (NACT) treatment was fermented without aeration for the same duration. The resulting compost tea solutions were then applied to maize plants according to the predetermined treatment doses, followed by observations of plant growth at several observation times.

III. RESULT AND DISCUSSION

Based on the research results and statistical analysis, compost tea application had a significant effect on all maize growth variables during the early growth phase (2–7 days after planting, DAP) as well as on root length ($P < 0.05$) (Table 1). In general, the aerated compost tea (ACT) treatment showed better growth responses than the non-aerated compost tea (NACT), particularly at lower concentrations. At 7 DAP, the ACT 60 ml treatment resulted in plant heights ranging from 13.5–21 cm and root lengths of 11.5–16.5 cm, whereas the NACT 60 ml treatment showed lower and more variable growth, with plant heights of 9.5–18 cm and root lengths of 10–17 cm. These differences indicate that aeration during compost tea preparation improves solution quality by increasing oxygen availability and aerobic microbial activity, which supports nutrient uptake and plant growth [4].

TABLE I. MEAN VALUES OF GROWTH PARAMETERS AND DUNCAN'S MULTIPLE RANGE TEST RESULTS (5% SIGNIFICANCE LEVEL).

Treatment	Plant Height (cm) Days After Planting (DAP)						Root Length (cm)
	2 DAP	3 DAP	4 DAP	5 DAP	6 DAP	7 DAP	
ACT 30 ml	0.54 a	2.39 a	5.49 a	9.45 a	14.12 ab	18.78 ab	17.18 a
ACT 60 ml	0.17 ab	1.21 b	3.94 b	7.24 b	11.75 bc	16.89 bc	14.75 b
NACT 30 ml	0.39 ab	2.09 a	5.21 a	8.94 ab	14.34 ab	19.52 a	16.89 ab
NACT 60 ml	0.08 ab	1.00 b	3.00 b	5.90 c	9.08 c	12.68 c	12.58 c
Control	0.00 b	1.14 b	4.46 ab	8.69 ab	18.21 a	19.49 a	17.55 a

However, statistical analysis also revealed that compost tea effectiveness was influenced not only by the aeration method but also by application concentration. During the early growth stage (2 DAP), the ACT 30 ml treatment produced the highest values and differed significantly from the control, indicating that aerated compost tea at low concentration effectively stimulated germination and early plant growth. At 3–4 DAP, ACT 30 ml and NACT 30 ml treatments still exhibited the highest growth and were not significantly different, while the 60 ml treatments tended to result in lower growth. From 5–7 DAP, plant growth under the control, ACT 30 ml, and NACT 30 ml treatments did not differ significantly, and at 7 DAP the control even showed comparable or higher values than high-concentration compost tea treatments.

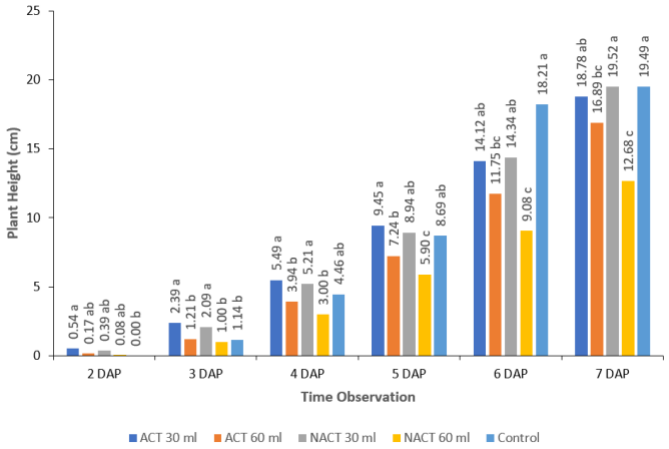

Fig. 1. Maize plant height from 2–7 days after planting under different compost tea concentrations.

This pattern suggests that compost tea primarily acts as an early growth stimulant, whereas at later growth stages plants are able to compensate through nutrient uptake from the growing medium. High concentrations, particularly in the NACT 60 ml treatment, tended to suppress growth, indicating possible inhibitory effects due to media imbalance or unfavorable microbial activity.

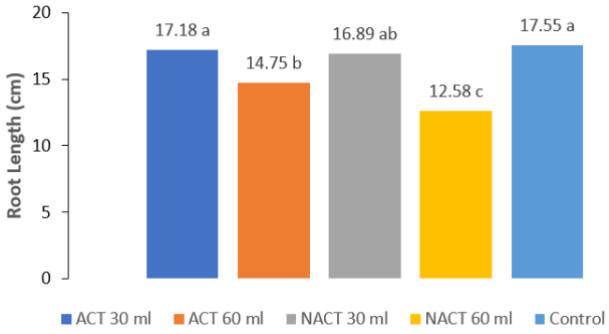

Fig. 2. Root length of maize plants at 7 days after planting under different compost tea concentrations.

A. Mode of Action of Compost Tea

Compost tea contains diverse microbial communities, including bacteria, fungi, and protozoa, which play crucial roles in nutrient cycling and enhancement of soil biological activity. These microorganisms contribute to organic matter decomposition, nitrogen fixation, phosphate solubilization, and the production of bioactive compounds that promote plant growth. Aeration during compost tea preparation increases the dominance of aerobic microorganisms, which are more efficient in supporting root respiration and nutrient uptake compared to non-aerated systems [4].

In addition to improving nutrient availability, compost tea also suppresses soil-borne pathogens through competition for space and nutrients, as well as the production of antibiotics and natural antimicrobial compounds. Yin et al. (2025) reported that compost tea contains various bioactive substances, such as plant hormones, antibiotics, organic acids, humic substances, and

enzymes (e.g., cellulase and phosphatase) produced by microorganisms. These compounds and enzymes contribute to organic matter transformation, nutrient release, and increased enzymatic activity in the rhizosphere. Enhanced alkaline phosphatase activity in the rhizosphere has been reported to promote root growth and improve phosphorus use efficiency in plants [10].

Nevertheless, the effectiveness of compost tea is strongly influenced by application concentration. At low to moderate concentrations, microorganisms and bioactive compounds act synergistically to stimulate plant growth. In contrast, at high concentrations—particularly in non-aerated compost tea—conditions such as oxygen deficiency, microbial imbalance, or accumulation of certain compounds may occur, potentially inhibiting root and shoot growth.

B. Effect of Compost Tea Concentration on Maize Growth

Differences in compost tea concentration significantly affected maize growth. The 30 ml concentration was more effective in enhancing plant height and root length compared to the 60 ml concentration. Optimal concentrations provide a balanced supply of beneficial microorganisms and dissolved nutrients, thereby increasing soil microbial activity, improving growing media conditions, and enhancing nutrient uptake efficiency by plants [3].

Conversely, high-concentration compost tea applications (60 ml), particularly under the NACT treatment, tended to reduce plant growth. This effect is likely associated with nutrient excess, changes in media pH, overly moist conditions, or reduced oxygen availability, all of which can inhibit plant physiological activity and root development. These findings confirm that increasing compost tea concentration does not necessarily result in improved plant growth.

Overall, the results indicate that compost tea—especially aerated compost tea at low concentrations—is more effective as an early growth stimulant for maize plants. To support long-term growth, compost tea application should be combined with appropriate soil fertility management. Therefore, further studies on optimal concentration, application frequency, and interactions between compost tea, environmental factors, and crop types are required to optimize its use in sustainable agricultural systems.

IV. CONCLUSIONS AND RECOMENDATION

Based on the results of this study, compost tea application significantly influenced early maize growth. Aerated compost tea (ACT) tended to produce better growth responses than non-aerated compost tea (NACT), particularly during the early growth stage. However, compost tea effectiveness was highly dependent on application dose, with lower concentrations showing more optimal growth responses than higher concentrations. Compost tea primarily functions as an early growth stimulant, while at later growth stages plants are able to compensate through nutrient uptake from the growing medium. Future studies are recommended to evaluate a wider range of compost tea concentrations and different application frequencies to determine the most effective optimal dose. In addition, further investigation into the microbial characteristics of compost tea and their interactions with different soil types and crops is necessary to optimize compost tea utilization in supporting sustainable agricultural systems.

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