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Enhancing BRIS Soil Sustainability through Biological Agent-drive Composting Approaches

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ABSTRACT

Beach Ridges Interspersed Swales (BRIS) soils are among the least fertile soil types in Malaysia due to poor nutrient content, low cation exchange capacity, and weak water-holding ability. At the same time, increasing organic food waste presents environmental challenges if unmanaged. Composting offers a dual solution by improving soil fertility and reducing waste accumulation. This study compared four composting approaches whereas: control, Vermicomposting, Black Soldier Fly (BSF) composting, and Effective Microorganisms (EM) composting by using a Randomised Complete Block Design (RCBD). The parameters that were observed are temperature, pH, and moisture content and monitored across the composting phases of mesophilic, thermophilic and curing stages. The findings revealed that BSF composting was the most effective technique by producing stable compost with favourable nutrient content (potassium and phosphorus) and faster decomposition. Vermicomposting ranked second, while EM and control treatments showed moderate improvements. Overall, these findings highlight the role of biological agents such as BSF larvae and earthworms in accelerating the composting process and improving the quality of the final product. Accordingly, BSF and vermicomposting are recommended for sustainable strategies for organic waste management and improving BRIS soil fertility.

Keywords: BRIS soil, composting, BSF, vermicomposting, effective microorganism, food waste management

INTRODUCTION

The global rise in organic food waste poses significant environmental and agricultural challenges. In Malaysia, food waste contributes substantially to municipal solid waste, while BRIS soils limit agricultural productivity due to their sandy texture (>90%), poor water retention, and low

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fertility (Yusoff et al., 2017). Composting represents a sustainable solution, reducing environmental burdens while enhancing soil fertility.

The efficiency of composting depends on multiple factors, including temperature, moisture, and pH. Optimal microbial activity requires moisture levels of 50–60% (Ameen et al., 2016), while temperature not only accelerates decomposition but also eliminates pathogens (Hafeez et al., 2018). A slightly alkaline pH promotes microbial decomposition, whereas acidic conditions slow it down. Biological agents such as earthworms and BSF larvae have shown potential to accelerate composting and improve nutrient enrichment.

This study systematically compares the effectiveness of BSF composting, vermicomposting, and EM composting in enhancing BRIS soil fertility.

Problem Statement

BRIS soil is unsuitable for sustainable agricultural practices. At the same time, the increasing generation of organic food waste poses a significant environmental challenge if left unmanaged. Composting has emerged as a promising approach to address both issues by converting organic waste into nutrient-rich material that can enhance soil fertility. However, the efficiency and quality of compost are highly dependent on the composting method employed. Biological agents such as BSF larvae and earthworms have demonstrated potential in accelerating decomposition and enhancing compost quality. Despite these advantages, limited research has systematically compare the effectiveness of different composting techniques, particularly in relation to their impact on BRIS soil fertility. This highlights the need for a comprehensive evaluation of composting methods to identify the most effective strategy for improving BRIS soil productivity while simultaneously promoting sustainable food waste management.

MATERIALS AND METHODS

Experimental Setup

The study was conducted at Universiti Sultan Zainal Abidin (UniSZA), under sheltered 10m2 structure to minimise weather influence. A Randomized Complete Block Design (RCBD) with four treatments (control, vermicomposting, EM, and BSF composting) replicated three times was used (12 units total) based on Karmegan et al. (2023).

Composting Treatments

Four composting treatments were applied in this study. In the vermicomposting treatment, kitchen waste was layered with BRIS soil and dried leaves at a 3:1 carbon-to-nitrogen ratio. Earthworms (Eisenia fetida) were introduced, and moisture was maintained through periodic watering to support their activity. For the Black Soldier Fly (BSF) composting

treatment, 150 larvae of Hermetia illucens were introduced into organic waste layered with BRIS soil, with continuous monitoring of moisture and larval health to ensure optimal decomposition. The Effective Microorganisms (EM) composting treatment involved the preparation of an EM solution consisting of 1 L of EM, 1 L of molasses, and 10 L of water. This solution was applied to layered organic waste, and the piles were turned regularly to promote aeration and ensure even microbial distribution. Finally, the control treatment relied solely on natural microbial decomposition without the addition of biological agents.

Data Collection

Temperature, pH, and moisture were recorded twice daily across mesophilic, thermophilic, and curing phases. Nutrient analysis was performed using ICP-OES.

RESULTS AND DISCUSSION

Composting Phases

All treatments followed typical composting phases. The mesophilic stage (Day 1–14) showed temperature rises as microbes decomposed readily available organic matter. Control bins exhibited the sharpest rise, while vermicomposting showed moderated increases due to worm activity. BSF composting displayed moderate heat increases, reflecting larval mechanical breakdown of waste.

In the thermophilic phase (Day 15–17), temperatures exceeded 40°C. Control reached the highest peak (35.5°C), followed by EM (34.3°C), vermicompost (33.8°C), and BSF (33.3°C). Moisture from vegetable-rich waste likely reduced oxygen, suppressing aerobic microbial activity (Jahan & Chowdury, 2015).

During curing (Day 19–35), vermicompost maintained gradual declines, BSF compost cooled rapidly as larval activity ceased earlier, and EM exhibited steady declines to ~27°C, indicating stable microbial decomposition.

Relationship between the Composting Technique and Each Parameter

Correlation analysis revealed strong positive relationships among composting parameters. Temperature trends across treatments were aligned, BSF and vermicomposting maintained more stable stable moisture and pH ranges. EM composting maintained smoother transitions, while control showed higher fluctuations.

Nutrient Enrichment

BSF and vermicomposting produced compost with improved nutrient profiles, notably potassium and phosphorus. Control treatment showed higher concentrations of certain macronutrients but lacked stability. The inclusion of eggshells also improved calcium availability for BRIS soils.

CONCLUSION

This study demonstrates that BSF composting is the most effective method for rapid decomposition and nutrient stabilisation, followed by vermicomposting. EM composting provided moderate benefits, while control treatment was least effective. Biological agents, particularly BSF larvae and earthworms, significantly enhance compost quality and decomposition rate. Integrating BSF and vermicomposting offers a sustainable strategy for managing food waste and improving BRIS soil fertility.

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