

Development And Optimization Of Liquid Bioorganic Fertilizer (LBF) From Agricultural Biomass Waste for Sustainable Vegetable Farming (Red Amaranth) via Box Behnken Design

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Structured Abstract

Background: The extensive use of chemical liquid fertilizers, particularly AB formulations, in vegetable cultivation has raised serious environmental concerns. These issues stress the importance of adopting sustainable and eco-friendly farming practices. This study aims to develop a Liquid Bioorganic Fertilizer (LBF) derived from underutilized biomass waste as a greener alternative. The research seeks to reduce reliance on chemical fertilizers and promote more sustainable hydroponic systems that are both environmentally responsible and agriculturally effective in supporting healthy plant growth.

Methods: Biomass wastes were chopped, ground, and undergo digestion with beneficial microbes for four weeks. Using response surface methodology with Box-Behnken design (BBD), 25 different formulations were prepared. Red Amaranth seeds were germinated until they reached 1–2 cm with visible leaves, then transplanted into hydroponic containers containing the respective formulations. After 14 days, root length, shoot length, and number of leaves were recorded. The data were analyzed using Minitab to generate main effect, interaction, surface, and contour plots. The response optimizer tool was applied to determine the optimal formulation.

Results: This study showed that combining biomass waste can effectively replace AB chemical fertilizers. Compared to AB fertilizer, Formulation 4 had the smallest growth difference, while Formulation 7 had the highest shoot and root length increases. Molasses, empty fruit bunch, and black soldier fly frass showed positive linear effects, meaning that it had synergistic interactions and increasing their concentration consistently enhanced plant growth. In contrast, rice straw, coconut husk, and oil palm husk displayed quadratic effects indicating growth improved at moderate levels. This indicates the presence of an optimal range. These trends were further visualized by surface and contour plots. The optimal formulation, identified using the response optimizer, will be used in future studies.

Conclusion: This study identified LBF formulation along with the optimal formulation using response surface methodology, which reducing reliance on chemical fertilizers and enhancing biomass waste utilization. Aligned with Malaysia's Biomass Action Plan 2023–2030, it advances biofertilizer innovation, promotes sustainable agriculture, and lowers hydroponic environmental impact. Further testing will validate the optimal formulation.

Keywords: Liquid Bioorganic Fertilizer (LBF), Biomass Waste, Red Amaranths, Box Behnken Design (BBD)

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