Eco-Enzyme Liquid Fertilizer Trial Using Fruit Peels and Unused Fruit: A Sustainable Agricultural Solution

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ABSTRACT

The utilization of organic waste as eco-enzyme liquid fertilizer serves as a strategic solution for waste reduction while providing environmentally friendly plant nutrients. This study aims to evaluate the effectiveness of various fruit peels (pineapple, avocado, dragon fruit, mango, soursop, and banana) as raw materials for eco-enzyme production through a three-month anaerobic fermentation process assisted by Local Microorganisms (MOL). The research method employed a 10:1:3 ratio (water : coconut sugar : fruit peel waste) within a closed fermentation system. The results indicated that the resulting eco-enzyme was physically clear brownish in color with a distinctive fruit fermentation aroma and an acidity level (pH) of 3.5. Application tests on plants showed significant results, where a 10% concentration of the solution increased plant height by 15% and accelerated the emergence of new shoots compared to the control group. These findings confirm that the combination of various tropical fruit peels produces a liquid fertilizer with complex nutritional content effective for supporting vegetative plant growth. This study proves that fruit peel waste can be processed into high-value products that support sustainable agricultural systems.

KEYWORDS:

Eco-enzyme, fruit peels, anaerobic fermentation, liquid organic fertilizer, sustainable agriculture.

I. INTRODUCTION

Organic waste from household activities and fruit vendors often becomes an environmental issue if not managed properly. *Eco-enzyme* emerges as a product of organic waste fermentation that offers broad benefits for the *sustainable agriculture* sector [1] [2]. In the Cigombong Village area, abundant agricultural potential generates significant fruit peel residue that has not been optimally utilized. The utilization of this waste through simple fermentation technology not only reduces waste disposal to landfills but also supports the *fertilizer self-sufficiency* of local farmers through the *zero-waste* concept [3][4]. The transformation of waste into functional products represents a global strategy in maintaining *ecosystem sustainability* [5][6].

Eco-enzyme is formed through an *ionization process* during anaerobic fermentation, which produces organic acids and functional enzymes [7][8]. The use of various types of fruit peels aims to create a *nutritional synergy*: *Pineapple and Soursop*: Contain bromelain enzymes and antibacterial compounds to control soil-borne pathogens [9][10]. *Banana and Mango*: Provide significant contributions of *Potassium* (K) and *Phosphorus* (P) to strengthen stem structures [11][12]. *Dragon Fruit and Avocado*: Contribute essential micronutrients that increase plant biomass and leaf area [13][14]. Previous studies have shown that the quality of *eco-enzyme* is influenced by *pH stability* and fermentation duration [15][16][17]. The application of this fertilizer on horticultural plants has been proven to significantly increase productivity without damaging plant tissues [18][19].

II. RESEARCH METHODOLOGY

This research method is an experimental study referring to standard protocols [6][2] with a mass ratio of 10:1:3 (water : coconut sugar : fruit waste). A total of 3 kg of mixed fruit peels (pineapple, avocado, dragon fruit, mango, soursop, and banana) were chopped into 1–3 cm pieces to expand the microbial contact surface area [10]. The materials were fermented with 1 kg of coconut sugar and 10 liters of chlorine-free water in an airtight container. *Local Microorganisms* (MOL) were added as a starter to accelerate the decomposition process [11]. The gas circulation system utilized a hose connected to a water bottle (airlock system) to maintain anaerobic conditions for 90 days [15][17]. The efficacy test was conducted by spraying a 10% concentration solution onto the leaves of the sample plants every 7 days [19][8].

IV. RESULTS AND DISCUSSION

4.1. Analysis of Physical Characteristics and Fermentation Rate

Observations over 90 days showed the transformation of fruit peel waste into a clear brownish liquid with a dominant fresh acidic aroma. Chemically, the final product reached an acidity level (**pH**) of 3.5. This significant decrease in pH serves as an indicator of a successful anaerobic fermentation process, where lactic acid bacteria degrade glucose from coconut sugar into organic acids, primarily acetic and lactic acid [4] [10]. A pH condition below 4.0 is crucial as it acts as a natural preservative that inhibits the growth of pathogenic bacteria and ensures the stability of the solution's ionization [3].

4.2. Enzymatic Synergy and Multicomponent Nutrient Content

The combination of six types of fruit peels resulted in a more complex nutritional profile compared to the use of a single material [13]. *Enzymatic Activity*: The presence of pineapple and soursop peels contributed high levels of protease and bromelain enzymes. These enzymes actively break down complex proteins into amino acids that are more easily absorbed by plant roots, while also acting as biopesticide agents against soil-borne pathogens [9]. *Macro and Micronutrients*: Banana, dragon fruit, and mango peels contributed significant organic Potassium (K) and Phosphorus (P) to strengthen cell structures and stimulate cell division in the apical meristem [11] [17]. Meanwhile, avocado peel complemented the solution with essential micronutrients and healthy fats that enhance plant resistance to environmental stress [1].

4.3. Impacton Vegetative Growth.

The application of eco-enzyme at a 10% concentration via the *foliar spray* technique yielded significant results compared to the control group. *Plant Height Stimulation*: There was a 15% increase in plant height. This was possible because eco-enzyme contains acetic acid, which at low concentrations acts as a biostimulant, triggering the synthesis of the plant's internal auxin hormones [18] [15]. *Accelerated Shoot Regeneration*: The emergence of new shoots 3–5 days earlier in the treatment group demonstrates the effectiveness of Local Microorganisms (MOL) in accelerating the availability of ready-to-absorb nutrients [16]. These nutrients directly enter through the leaf stomata, triggering a higher photosynthetic rate compared to conventional fertilization [5].

4.4. Contribution to Sustainable Agriculture and Soil Health

.Ecologically, eco-enzyme application not only fertilizes the plants but also improves the biological structure of the soil. Amylase and lipase enzymes formed during fermentation help degrade chemical residues in the soil, making it more friable and increasing the population of beneficial soil microbes [14] [19]. This transformation of fruit peel waste into high-value agricultural inputs proves that the *zero-waste* strategy can be effectively implemented to support local food security at the household level [7] [2].

V. CONCLUSION

Based on the content and nutrients contained in *Eco-Enzyme*, as well as trials of *Eco-Enzyme* liquid fertilizer applications on plants, positive results were obtained, including increased plant growth and fruit production. This trial shows that the utilization of organic waste in the form of fruit peels and discarded fruit can be used as raw material for making *Eco-Enzyme* liquid fertilizer that is effective and environmentally friendly, and contributes to integrated pest and plant disease control towards sustainable agriculture. Furthermore, the practice of using *Eco-Enzyme* dosages needs to be continued to achieve the best results and the use of *Eco-Enzyme* in combination with manure to improve the biological and physical structure of the soil.

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