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Potential of Fruit and Vegetable Waste as Eco-enzyme Fertilizer for Plants

Thanya Fadlilla[1*], MTh Sri Budiastuti[1], MMA Retno Rosariastuti[2]

[1] Study Program of Environmental Science, Postgraduate School, Sebelas Maret University, Surakarta, Indonesia
[2] Study Program of Soil Science, Faculty of Agriculture, Sebelas Maret University, Surakarta, Indonesia

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Corresponding Author:
Thanya Fadlilla
tanyaaku02@gmail.com

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Abstract: This study aims to determine the source of eco-enzyme raw materials and the most appropriate dilution volume to produce quality eco-enzyme fertilizer for plant growth. 1 (sugar): 3 (fruit and vegetable waste): 10 (water). The resulting eco-enzyme liquid is processed into fertilizer through the dilution process. Eco-enzyme fertilizers from each raw material source contain different organic N, P, K, and C nutrients. Besides that, some enzymes are beneficial to plants. This research is experimental in the laboratory. The experimental design was factorial design using a completely randomized design as the based design with the treatment of various sources of raw material for eco-enzyme E1 (fruit waste), E2 (vegetable waste), and E3 (fruit and vegetable waste). The parameters observed are N, P, K, and C Organic. The results showed that in terms of the quality of eco-enzyme fertilizers, the best order of eco-enzyme fertilizers was eco-enzyme fertilizer from vegetable waste (E2), eco-enzyme fertilizer from fruit and vegetable waste (E3), and eco-enzyme fertilizer from fruit waste (E1). Based on the NPK content in eco-enzyme fertilizer, eco-enzyme fertilizer is still below the quality standard for liquid organic fertilizer but the enzymes contained in eco-enzymes can also spur growth in plants.

Keywords: Eco-enzyme; Eco-enzyme Fertilizer; Environment; Fruit Waste; Vegetable Waste

Introduction

Fruits and vegetables are essential needs in human life. Daily utilization of fruits and vegetables will leave waste in fruit peels or leftover fruit and vegetable ingredients that are no longer suitable for consumption so they will become waste. Organic waste is often a problem that is frequently encountered in urban and rural society. Organic waste is a type of waste that consists of organic compounds and can be decomposed/easily degraded naturally or by living organisms (especially microorganisms) (Monita et al., 2017). Waste contributes to environmental pollution because it produces an unpleasant odor, can contaminate water and soil, and reduce the environment's beauty. Vegetable and fruit waste is often disposed of in open landfills without further processing, disturbs the environment, and creates odors. The nutrients in fruit waste are low, namely 5 to 38% crude fiber and 1 to 15% crude protein (Nasrun et al, 2016). According to data collected by Pramono (2004) of total organic waste, about 60% is vegetable waste, and 40% is waste leaves, fruit peels, and food waste. The more household activities are carried out. The more plant waste is produced, this is the cause of piles of garbage that rot and emit an unpleasant odor, pollute the environment and cause diseases that affect public health (Ekawandani & Alvianingsih, 2018). The accumulation of waste, especially plant waste, must be managed properly and correctly. If this is not combined with proper waste management, it will cause environmental problems and pollution (air, soil, and water).

Waste management includes the disposal of waste in the containers provided, collection, transfer, and transportation of waste, as well as the waste processing for the final disposal process (Sahil et al., 2016). Lack of

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waste management planning leads to an optimal waste management system. In addition, the lack of Final Disposal Sites is a fundamental problem (Sari, 2016). Waste management is influenced by several factors that are considered systemic obstacles, namely the distribution and population, physical characteristics, attitudes, behavior, environment, and socio-economic community (Sahil et al., 2016). One of the uses of fruit and vegetable peel waste is to turn it into eco enzymes. The waste is then mixed with sugar and water. In the fermentation process, O3 gas (ozone) is produced, resulting in a cleaning liquid and fertilizer (Megah et al., 2018). During fermentation, carbohydrates turn into volatile acids, and organic acids in the waste materials also dissolve in the fermentation broth because eco enzymes are acidic.

Eco-enzyme provides the most significant impact in reducing or preventing pathogens because the acidic nature of eco enzymes helps separate extracellular enzymes from organic wastes during fermentation. During fermentation, glucose breaks down into pyruvic acid. Under anaerobic conditions, decarboxylated pyruvate decomposes into ethanol and carbon dioxide. The Acetobacter bacteria convert alcohol into acetaldehyde and water, which then becomes acetic acid (Supriyani et al., 2020). Eco-enzyme includes functional enzymes such as amylase, lipase, caseinase, protease, and cellulase, as well as secondary metabolites such as flavonoids, quinones, saponins, alkaloids, and cardio glycosides (Vama & Cherekar, 2020). In the environmental field, eco enzymes can be used as ecological cleaning agents, aromatherapy, reducing environmental toxicity in agriculture, and as various liquid plant fertilizers (Hemalatha & Visantini, 2020). Eco enzymes as organic fertilizers for plants must be supplemented with water. The benefits of eco enzymes in agriculture were that the application of eco enzymes from pineapple peels had a good effect on the growth of chili plants characterized by greater height. Stem diameter, leaf width, and greener color compared to plants without eco enzyme fertilizer (Ramadani et al., 2019).

Based on the description above, eco enzymes have advantages. They can be utilized in the environment, but there is still little information about using fruit and vegetable waste as eco-enzyme fertilizers. It is necessary to research the "Potential of Fruit and Vegetable Waste as Eco enzyme Fertilizer for Plants" by analyzing the quality of fertilizers' eco enzymes from several different raw materials. At the time of manufacture, the raw materials come from several types of fruit, vegetables, and a combination of fruits and vegetables. With the different kinds of eco-enzyme materials, it is hoped that they will have other effects on the quality of fertilizers so that optimal raw materials are obtained as eco-enzyme fertilizers for plants. The results of laboratory analysis of nitrogen (N), Phosphorus (P), Potassium (K), and C-organic nutrients were compared with the quality standards for the Minimum Technical Requirements for Organic Fertilizers, Biofertilizers and Soil Improvers issued by Regulation of the Minister of Agriculture of the Republic of Indonesia No. 261 of 2019.

Method

Location and Time of Study

This research was conducted from March to July 2022 in Palembang City, South Sumatra Province, Indonesia. Sample analysis was carried out at the Testing Laboratory of the Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University.

Tools and Materials

The tools used in this research were closed plastic drums measuring 25 L, stirrers, knives, cutting boards, scales, spectrophotometers, titrators/burets, digestion apparatus, Atomic Absorption Spectrophotometer (AAS), Erlenmeyer 100 ml, filter paper, and volumetric flasks 50 ml. The materials used in this study were fruit and vegetable waste from households in Palembang city, brown sugar (from home traders), well water (from a resident's house), H2SO4, 40% NaOH, 0.05N H2SO4, FeSO4 0 .5 N and distilled water.

Research Procedures

Making Eco-enzyme Fertilizer

The process of making eco-enzyme fertilizer begins with collecting fruit and vegetable waste that is still fresh and not rotten, then washing it clean and weighing it. Washed vegetable waste is put into the drum together with water and thinly sliced brown sugar with a ratio of 1 sugar: 3 organic wastes: 10 water. The drum is tightly closed and stored in a place that is not exposed to direct sunlight or rain. In the first month, the drum lid is routinely opened once a day; stirring was carried out for 15 minutes to remove the gas, after which the drum was closed again. In the second month, the drum mixing was not done. The fermentation process will end in the 3rd month.

Harvesting Eco-enzyme Fertilizer

Eco-enzyme fertilizer was harvested after three months fermentation by filtering or separating the eco-enzyme liquid and eco-enzyme waste. The use as a fertilizer for plants is carried out with a dilution process first, including 1:0 ml dilution (P0), 1:1500 ml dilution (P1), 1:1000 ml dilution (P2), and 1:500 ml dilution (P3).

Nutrient content of Vegetable Eco-enzyme

Eco enzyme fertilizer before and after dilution was analyzed in the laboratory for several parameters tested, namely the content of Nitrogen (N), Phosphorus (P), Potassium (K), and C-Organic.

Laboratory analysis and plant observation

N content (Kjeldahl method), P content (Wet oxidation), K content (Wet oxidation), and C-organic (Walkey and Black method).

-Data Collection Method

Data were analyzed statistically using Analysis of variance (ANOVA) (with a 95% confidence level) followed by the Duncan Multiple Range Test (DMRT).

Data Analysis Method

This research is experimental in the laboratory. The experimental design was factorial design using a completely randomized design as the based design with the treatment of various sources of raw material for eco-enzyme E1 (fruit waste), E2 (vegetable waste), and E3.

The main component of eco-enzyme fertilizer is organic waste from fruits and vegetables, which contain lots of nutrients needed by plants. Table 1 shows that the nutrient content of eco-enzyme fertilizers from fruit sources was lowest in each dilution compared to vegetable raw material sources and fruit and vegetable mixtures. Eco-enzyme fertilizers made from vegetable raw materials and fruit and vegetable ingredients contain almost the same nutrients. Eco enzyme fertilizers contain different Nitrogen(N), Phosphorus(P), Potassium(K), and C-organic in each dilution volume treatment. Based on the Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers and Soil Repairers issued by Regulation of the (fruit and vegetable waste). The parameters observed are N, P, K, and C Organic. This research design was factorial with the basic design of Completely Randomized Design (CRD) with two factors.

The first factor is Eco-enzyme raw materials consisting of 3 levels, namely eco-enzyme with fruit waste as raw material (E1), Eco-enzyme with vegetable waste raw materials (E2) and Eco-enzyme made from fruit and vegetable waste as raw material (E3). The second factor is the Dilution Type of Eco-enzyme as Fertilizer which consists of 4 levels, namely eco-enzyme fertilizer without dilution (P0), eco-enzyme fertilizer with 1:1500 dilution (1 ml Eco-enzyme + 1500 ml water) (P1), eco-enzyme ertilizer with 1:1000 dilution (1 ml Eco-enzyme + 1000 ml water) (P2), and eco-enzyme fertilizer with 1:500 dilution (1 ml Eco-enzyme + 500 ml water) (P3).

Result and Discussion

Nutrient Content of Eco-enzyme Fertilizer

The results of the laboratory analysis of the nutrient content of eco-enzyme fertilizers can be seen in Table 1.

Table 1. Nutrient content of Eco-enzyme Fertilizer

Eco-enzyme Fertilizer	pH	N (%)	P (%)	K (%)	Total NPK	Total Quality Standard NPK	Result C-organic (%)	Quality Standard C-organic
E1P0	2.3a	0.02a	0.01d	0.06c	0.09b	2-6	1.33b	min*10
E1P1	5.2f	0.01a	0.000009b	0.000133b	0.01a	2-6	0.01a	min*10
E1P2	5.1e	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E1P3	4.9d	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E2P0	2.4b	0.03a	0.02a	0.1e	0.1c	2-6	1.975c	min*10
E2P1	5.2f	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E2P2	5.1e	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E2P3	4.9d	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E3P0	2.5c	0.02a	0.005c	0.07d	0.1c	2-6	2.13d	min*10
E3P1	5.2f	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E3P2	5.1e	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10
E3P3	4.9d	0.01a	0.000008a	0.000008a	0.01a	2-6	0.01a	min*10

Source: Analysis Result of the Testing Laboratory of the Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University 2022

Minister of Agriculture of the Republic of Indonesia No. 261 of 2019, the nutrients contained in eco-enzyme fertilizers are still below the quality standards for liquid organic fertilizers. On average, the NPK nutrient content of eco-enzyme fertilizers is less than 2%, and Organic C is less than 10%. This concentration can affect plant growth, where the NPK nutrients contained in eco-enzyme result from the decomposition and mineralization of organic matter. Adding sugar to eco-enzyme is a breeding ground for bacteria to live and reproduce. The enzymes contain lipase, trypsin, and amylase, which can kill and prevent pathogenic bacteria. The process of making eco-enzyme produces NO_3 (nitrate) and CO_3 (carbon trioxide), which are needed by the soil as nutrients (Sulaeman, 2019). This confirms that eco-enzyme liquids can be used as plant fertilizers.

NPK is a nutrient required in large quantities for plant growth and development. Research on the production and characterization of eco-enzyme from orange and tomato peels (Rasit *et al.*, 2019). States the concentration of eco-enzyme, from the expected results, it is known that the enzymes produced have acidic properties and contain biocatalytic enzyme activity (protease, amylase and lipase). In addition, the use of pineapple peel eco-enzyme in agriculture has shown a positive effect on the growth of chili plants (Tong & Liu, 2020). The average fruit peel produces around 10.40 to 16.76% pectin (Tang & Tong, 2011). As a bioaugmentation agent, eco-enzyme fertilizer is expected to reduce the effectiveness of soil pollutants. Soil treated with eco-enzyme proves that there is a natural effect on the growth of chilies and aloe vera (Hemalatha & Visantini, 2020). They used eco-enzyme as eco-enzyme fertilizer is highly recommended to maintain environmental quality and increase soil fertility. The following describes the quality of eco-enzyme fertilizer in each parameter for all treatments.

Eco-enzyme Fertilizer Quality

Nitrogen (N)

ANOVA results showed that the eco-enzyme treatment and dilution significantly affected the amount of nitrogen in the eco-enzyme e fertilizer ($P < 0.05$). The interaction between eco-enzyme e fertilizer and dilution had no significant effect on the amount of nitrogen in eco-enzyme e fertilizer ($P > 0.05$). The following is the average yield of eco-enzyme raw materials to total N (Figure 1).

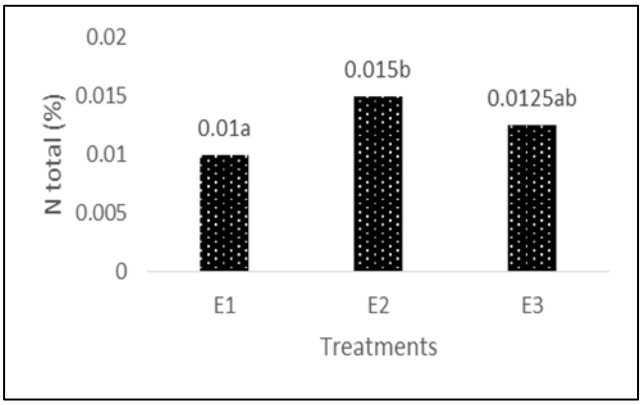

Figure 1. Effect of Eco-Enzyme E Raw Materials on Total N
*E1 (Fruit Eco-enzyme Fertilizer), E2 (Vegetable Eco-enzyme Fertilizer), and E3 (Fruit and Vegetable Eco-enzyme Fertilizer)

Based on Figure 1, it can be seen that treatment E2 (vegetable eco-enzyme fertilizer) gave the highest average of 0.015% or 50% higher than treatment E1 (fruit eco-enzyme fertilizer) and 20% higher than treatment E3 (fruit and vegetable eco-enzyme fertilizer). According to the DMRT treatment, E2 (vegetable eco-enzyme fertilizer) was not significantly different from E3 (fruit and vegetable eco-enzyme fertilizer). The E2 treatment is the most efficient eco-enzyme fertilizer in providing N nutrients.

Vegetable waste contains compounds and various decomposing bacteria that can increase soil fertility by providing the nutrients the soil needs (Mangkunegara, 2008). Vegetable waste has a high-water content, carbohydrates, protein, fat, fiber, phosphorus, iron, potassium, calcium, vitamin A, vitamin C and vitamin K. These elements have functions that can help the process of plant growth and reproduction because they are rich in nutrients needed by plants (Setyo & Nurhidayat, 2006). Vegetable waste contains organic substances such as nitrogen, stimulating the growth of stems, branches, and leaves. Nitrogen is required to form 1-4% of dry plant material such as stems, skins, and seeds. Nitrogen in organic matter is still in the form of protein, but nitrogen taken directly from plants is nitrogen in the form of nitrate (NO^{3+}) or ammonium (NH^{4+}) or compounds resulting from carbohydrate metabolism. Plants are in the form of amino acids and proteins (Sofian, 2006). The N nutrient content in eco-enzyme e fertilizers decreased with increasing dilution doses. This can be seen in Figure 2.

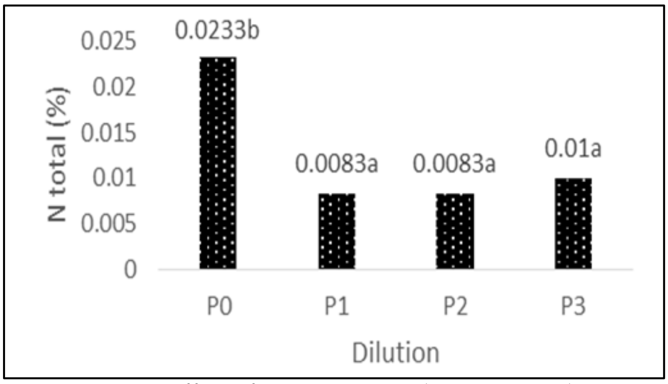

Figure 2. Effect of Eco-enzyme Dilution on total N
* P0 (1:0), P1 (1:1500), P2 (1:1000) and P3 (1:500)

Based on Figure 2, it can be seen that treatment P0 (without dilution) gave the highest average of 0.0233% or 33.29% higher than treatment P1 (1:500 dilution) and P2 (1:1000 dilution) and 57.08% higher than treatment P3 (1:1500 dilution). The volume of eco-enzyme dilution to obtain the maximum nutrient N is 0 ml. In this case the P1 treatment (1:500 dilution), P2 (1:1000 dilution) and P3 treatment (1:1500 dilution) were not significantly different.

According to Yuwono (2006), organic matter as a source of nitrogen, namely protein, is first broken down by microorganisms into amino acids, known as the amination process. Natural nitrogen content has also been incorporated into plant wastes, resulting in nitrogen enrichment during decomposition. Microbes use C elements for energy and NPK elements for growth, metabolism, and reproduction (Djaja et al, 2009). Nitrogen is a primary macronutrient crucial for developing shoots, stems, and leaves, which are very important for plants in the growth phase.

In the soil, nitrogen dramatically affects plant growth (Sutanto, 2002). The N element in eco-enzyme es is a nitrogen element that plants can directly absorb because it is in the form of NO^3 (nitrate). According to (Hasiholan et al, 2011), giving plants NO^{3-} (nitrate) can increase the activity of plant protein synthesis. The proteins formed are mainly used to create protoplasm in plant cells, leading to cell division and directly affecting the number of plant cultures. Nitrogen contained in eco-enzyme es in the form of nitrate (NO^3) acts as a protein component. At the same time, enzymes play a role in encouraging meristem division and stimulating root and leaf growth (Rahayu et al, 2021). As a result, plant nutrients and water absorption reach optimal limits and is available for cell division, elongation, and differentiation. In addition, this increase in wet weight is caused by improvements in the physical and chemical properties of the soil due to the action of eco-enzyme es such as the effectiveness of improving soil aeration, the role of increasing soil cation exchange capacity (CEC) (Hasanah, 2021). Because of the importance of the N content in eco-enzyme fertilizer, when applying eco-enzyme as fertilizer it is necessary to pay attention to the dilution factor so that the N content in eco-enzyme fertilizer is not too low.

Phosphorus (P)

ANOVA results show that eco-enzyme treatment, dilution, and interaction of the two had a significant effect on the phosphorus nutrient of eco-enzyme fertilizer ($P < 0.05$). The following is the average yield on eco-enzyme es (Figure 3).

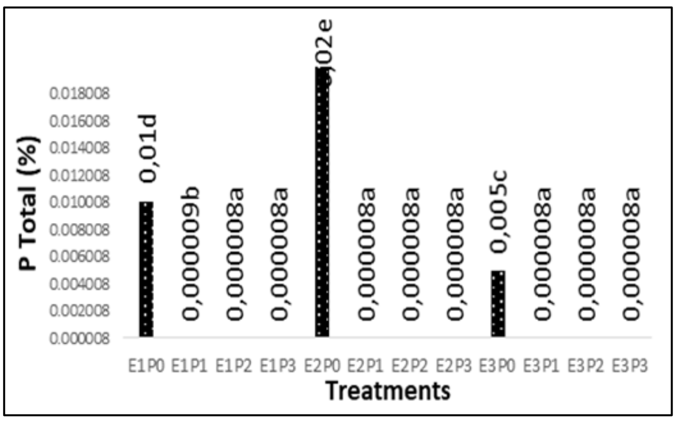

Figure 3. Effect of Eco-enzyme e Interaction and Dilution on Phosphorus

*E1P0 (Fruit Eco-enzyme Fertilizer with 1:0 dilution), E1P1 (Fruit Eco-enzyme Fertilizer with 1:1500 dilution), E1P2 (Fruit Eco-enzyme Fertilizer with 1:1000 dilution), E1P0 (Fruit Eco-enzyme Fertilizer with 1:500 dilution), E2P0 (Vegetable Eco-enzyme Fertilizer with 1:0 dilution), E2P1 (Vegetable Eco-enzyme Fertilizer with 1:1500 dilution), E2P2 (Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), E2P3 (Vegetable Eco-enzyme Fertilizer with 1:500 dilution), E3P0 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:0 dilution), E3P1 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1500 dilution), E3P2 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), and E3P3 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1000 dilution).

Based on Figure 3, it can be seen that the E2P0 treatment (Vegetable Eco-enzyme Fertilizer with 1:0 dilution) gave the highest average of 0.02% or 50% higher than the E1P0 treatment (Fruit Eco-enzyme Fertilizer with 1:0 dilution), 75% higher than treatment E3P0 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:0 dilution), and 99.96% higher than other treatments. According to DMRT treatment E1P0 (Fruit Ecoenzym Fertilizer with 1:0 dilution), E1P1 (Fruit Ecoenzym Fertilizer with 1:1500 dilution), E2P0 (Vegetable Ecoenzym Fertilizer with 1:500 dilution), and E3P0 (Fruit and Vegetable Ecoenzym Fertilizer with dilution 1:0) significantly different from other treatments.

Vegetable waste contains minerals and nutritional components such as thiamin, vitamin A, riboflavin, iron, phosphorus, potassium, ascorbic acid, folic acid, magnesium, and manganese (Safuan et al, 2012). The phosphorus in vegetables is the second most crucial element after nitrogen. The phosphate content in the soil that plants can absorb is only 15 to 20%, while the rest is absorbed between the soil colloids. To overcome this, one of the needs of phosphorus for plants is by providing organic fertilizers that contain organic acids that can be secreted and increase the solubility of phosphate in the soil and can be used as a nutrient for plant growth (Kaswinarni et al, 2014).

To determine the effect of the treatment can be seen in the regression graph. Following are the results of the total P regression in each treatment (Figure 4)

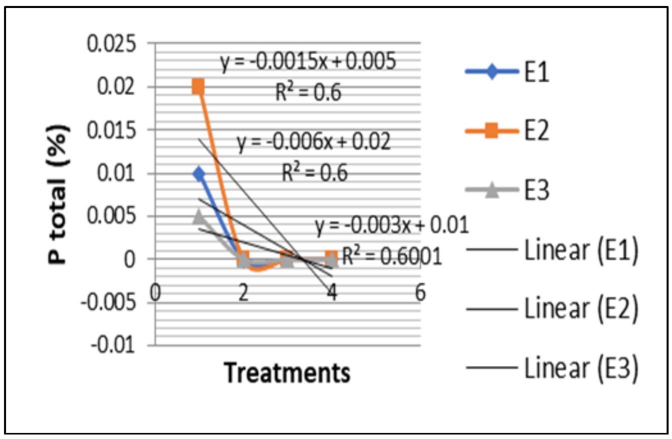

Figure 4. Total P Regression

*E1 (Fruit Eco-enzyme Fertilizer), E2 (Vegetable Eco-enzyme Fertilizer), and E3 (Fruit and Vegetable Eco-enzyme Fertilizer)

Based on Figure 4, it can be seen that the treatment has an effect of 60% on P Total. Other factors outside the research parameters influence the additional 40%. Phosphorus compounds also play a role in cell division, stimulating early root growth, fruit ripening, cellular energy transport, fertilization, and seed formation (Yulipriyanto, 2010). Phosphorus is considered the key to plant life. P contains essential nutrients for plants and functions to transfer energy to parts of the gene that other nutrients cannot replace. The role of P in energy storage and transfer is an essential function because it affects many different processes in plants (Yuwono, 2006).

Vegetable waste contains organic matter, including phosphorus, which promotes the formation of roots or tubers, flowers, and fruit and strengthens stems. Phosphorus cannot be absorbed by plants directly because it is still a compound that must be broken down into phosphate ions quickly absorbed by plants, namely H2PO4 and HPO42 (Aprinda, 2018). Eco-enzyme fertilizer can provide plant growth with NPK nutrients because the essential components of eco-enzyme fertilizer come from substances rich in nitrogen, phosphorus, and potassium, so when these substances meet in the fermentation process, the concentration of these elements will increase.

According to Lingga (2013), adding nutrients to liquid organic fertilizers containing nitrogen and protein-degrading enzymes in fertilizers stimulates root growth. It increases the amount of phosphorus (P) which is helpful for the development of plant roots, especially seed roots and young plants.

Potassium (K)

The results of ANOVA showed that the eco-enzyme dilution treatment and the interaction between the two had a significant effect on the potassium nutrient of eco-enzyme fertilizer ($P<0.05$).

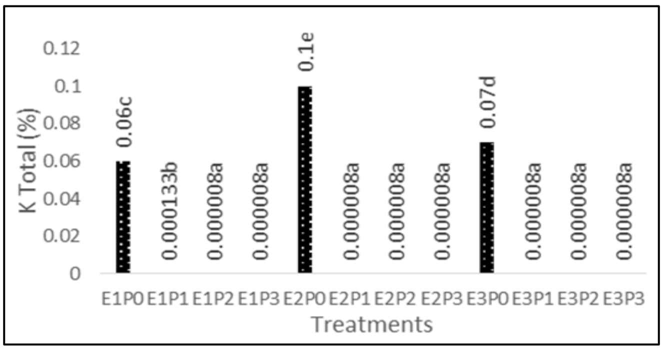

Figure 5. Effect of Eco-enzyme Interaction and Dilution on Potassium

*E1P0 (Fruit Eco-enzyme Fertilizer with 1:0 dilution), E1P1 (Fruit Eco-enzyme Fertilizer with 1:1500 dilution), E1P2 (Fruit Eco-enzyme Fertilizer with 1:1000 dilution), E1P0 (Fruit Eco-enzyme Fertilizer with 1:500 dilution), E2P0 (Vegetable Eco-enzyme Fertilizer with 1:0 dilution), E2P1 (Vegetable Eco-enzyme Fertilizer with 1:1500 dilution), E2P2 (Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), E2P3 (Vegetable Eco-enzyme Fertilizer with 1:500 dilution), E3P0 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:0 dilution), E3P1 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1500 dilution), E3P2 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), and E3P3 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1000 dilution).

Based on Figure 5, it can be seen that the E2P0 treatment (Vegetable Eco-enzyme Fertilizer with 1:0 dilution) gave the highest average of 0.1% or 30% higher than the E3P0 treatment (Fruit and vegetable eco-enzyme fertilizer), 40% higher than the E1P0 treatment (Fruit Eco-enzyme Fertilizer with 1:0 dilution) and 99.87% compared to the E1P1 treatment (Fruit Eco-enzyme Fertilizer with 1:1500 dilution) and 99.92% compared to other treatments. According to DMRT treatment E1P0 (Fruit Ecoenzym Fertilizer with 1:0 dilution), E1P1 (Fruit Ecoenzym Fertilizer with 1:1500 dilution), E2P0 (Vegetable Ecoenzym Fertilizer with 1:500 dilution), and E3P0 (Fruit and Vegetable Ecoenzym Fertilizer with dilution 1:0) significantly different from other treatments.

Fruit waste contains Nitrogen (N), Phosphorus (P), Potassium (K), Vitamins, Calcium (Ca), Iron (Fe), Sodium (Na), Magnesium (Mg), etc. This content is beneficial for soil fertility (Nur 2019). Vegetable waste contains fiber, phosphorus, iron, potassium, calcium, and vitamins which can help plant growth and reproduction (Setyo & Nurhidayat, 2006). Potassium acts as an activator of various enzymes that are essential in photosynthetic and respiration reactions and for enzymes involved in protein and starch synthesis. The vital role of the element potassium is as a binder between phospholipid molecules and membrane constituent proteins, which causes the membrane to function normally in all cells. Potassium can also stimulate the activity of several enzymes while at the same time inhibiting the activity of several other enzymes (Kaswinarni et al, 2014). To determine the effect of the treatment can be seen in the regression graph. Following are the results of the regression of Total Potassium in each treatment (Figure 6).

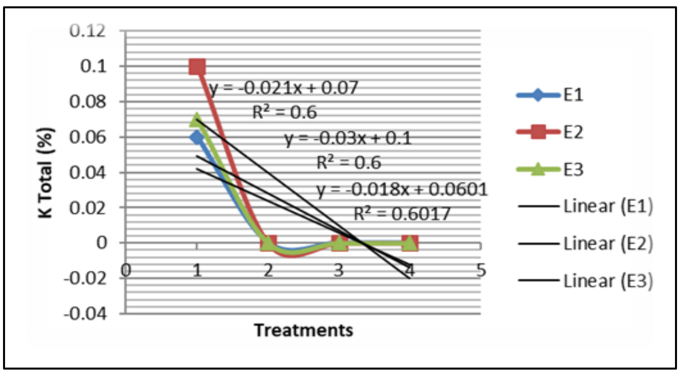

Figure 6. Regression K Total

*E1 = Fruit Eco-enzyme Fertilizer, E2 = Vegetable Eco-enzyme Fertilizer and E3 = Fruit and Vegetable Eco-enzyme Fertilizer

Based on Figure 6, it can be seen that the treatment has an effect of 60% on K Total. Other factors outside the research parameters influence the additional 40%. Potassium (K) is involved in forming proteins and carbohydrates, hardening woody parts, and improving the quality of seeds and fruits in plants. Potassium is vital in plant growth and influences water use efficiency. The process of opening and closing stomata is regulated by the K content of the cells surrounding the stomata. Potassium cannot be absorbed directly by plants. This is because compounds must be broken down into K ions to absorb them easily (Yuliani, 2017). Potassium contained in organic matter can dissolve after immersion in water. In this case, the immersion water contains potassium elements. Potassium is a catalyst for microorganisms to accelerate fermentation. Found that microorganisms use potassium (K_2O) as a substrate catalyst, and the presence and overall activity of bacteria significantly affect the increase in potassium concentration (Hidayati, 2013). Bacteria and fungi bind and store potassium in cells, and when it is broken down again, potassium becomes available again (Mirwan & Rosariawari, 2012). Potassium is a source of energy that helps plants fight drought and disease (Tong & Liu, 2020).

C-Organic

The results of ANOVA showed that the eco-enzyme e dilution treatment and the interaction between the two significantly affected the organic C nutrient of the eco-enzyme fertilizer (P <0.05).

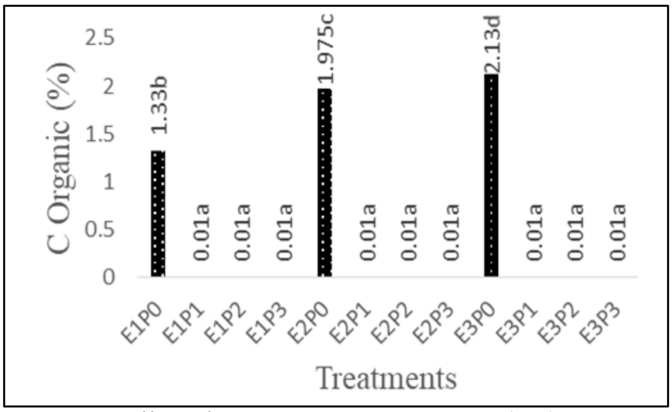

Figure 7. Effect of Eco-enzyme Interaction and Dilution on Organic

*E1P0 (Fruit Eco-enzyme Fertilizer with 1:0 dilution); E1P1 (Fruit Eco-enzyme Fertilizer with 1:1500 dilution); E1P2 (Fruit Eco-enzyme Fertilizer with 1:1000 dilution), E1P0 (Fruit Eco-enzyme Fertilizer with 1:500 dilution); E2P0 (Vegetable Eco-enzyme Fertilizer with 1:0 dilution), E2P1 (Vegetable Eco-enzyme Fertilizer with 1:1500 dilution); E2P2 (Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), E2P3 (Vegetable Eco-enzyme Fertilizer with 1:500 dilution), E3P0 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:0 dilution); E3P1 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1500 dilution), E3P2 (Fruit and Vegetable Eco-enzyme Fertilizer with 1:1000 dilution), and E3P3 (Fruit and Vegetable Eco-enzyme Fertilizer with dilution 1:500).

Based on Figure 7, it can be seen that the E3P0 treatment (Fruit and Vegetable Eco-enzyme Fertilizer with 1:0 dilution) gave the highest average of 2.13% or 37.5% higher than the E1P0 treatment (Fruit Eco-enzyme Fertilizer with 1:0 dilution), 7.27% higher compared to the E2P0 treatment (Vegetable Eco-enzyme Fertilizer with 1:0 dilution) and 99.53% compared to other treatments. According to DMRT treatment E1P0 (Fruit Ecoenzym Fertilizer with 1:0 dilution), E1P1 (Fruit Ecoenzym Fertilizer with 1:1500 dilution), E2P0 (Vegetable Ecoenzym Fertilizer with 1:500 dilution), and E3P0 (Fruit and Vegetable Ecoenzym Fertilizer with dilution 1:0) significantly different from other treatments. To determine the effect of the treatment can be seen in the regression graph. Following are the results of the Organic C regression in each treatment (Figure 8)

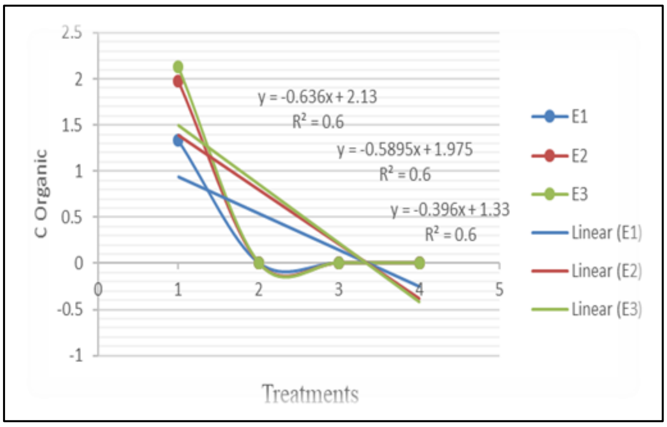

Figure 8. Effect of Eco-enzyme Interaction and Dilution on Organic C

*E1 = Fruit Eco-enzyme Fertilizer, E2 = Vegetable Eco-enzyme Fertilizer and E3 = Fruit and Vegetable Eco-enzyme Fertilizer

Based on Figure 8 it can be seen that the treatment has an effect of 60% on Organic C. Other factors outside the research parameters influence the additional 40%. The element carbon plays an essential role in plants, namely as a building block for organic matter because most plants' dry weight consists of organic matter. In addition, microorganisms require carbon as an energy source (Sutanto, 2002). Wahyudi (2009) found that the increase in C-organic concentration was due to the presence of carbon (C), which is the main component of the organic matter itself. The increase in organic matter is directly proportional to the increase in organic C in the soil. Therefore, the mixture of fruit and vegetable waste becomes organic matter through a fermentation process, which means that the application of eco-enzyme e fertilizers to the soil increases the amount of organic matter in the soil. When organic matter decomposes, several carbons compounds, such as CO_2, CO_3, HCO_3, CH_4, and C are formed (Yudhi & Bertham, 2002). Eco-enzyme fermentation produces several essential organic acids such as acetic acid, lactic acid, malic acid, oxalic acid, and citric acid. The pH conditions of the eco-enzymes are classified as acidic. The type of bacteria involved will determine acetic acid production during the fermentation process.

Enzymes are the primary key to synthesizing plant compounds (Prasetya, 2014). The addition of organic fertilizer from agricultural waste, namely eco-enzymes, contains the enzymes α-amylase, maltase, and protein degrading enzymes. This enzyme plays a role in breaking down starch compounds contained in the food endosperm into glucose compounds. Glucose is a source of energy for plant growth (Ginting *et al*., 2021). Ecoenzymes can be used as fertilizers because they contain macro- and micro-organisms that convert ammonia into nitrate (NO3), natural hormones, and plant nutrients (Indrajaya & Suhartini, 2018). Chemically, eco enzymes are complex organic compounds consisting of protein chains and mineral salts. Ecoenzymes help fertilize soil and plants, control pests and improve the quality and taste of grown fruits and vegetables (Baharu, 2018). Based on the description above, the enzymes contained in eco-enzymes can also spur growth in plants.

Conclusion

The manufacture of eco-enzyme fertilizers from several types of waste, including fruit waste (E1), vegetable waste (E2), and mixed fruit and vegetable waste (E3), contain plant nutrients needed by plants even though they are still below the quality standard of liquid organic fertilizer. The best order is Fertilizer E2, E3, and E1. N nutrient content in eco-enzyme fertilizer from vegetable waste with a 1:0 dilution (E2P0) is 50% higher than that in eco-enzyme fertilizer from fruit waste with a 1:0 dilution (E1P0) and 20% higher than eco-enzyme fertilizer from fruit and vegetable waste with a 1:0 dilution (E3P0). The P nutrient content in eco-enzyme fertilizer from vegetable waste with a 1:0 dilution (E2P0) is 50% higher than that in eco-enzyme fertilizer from fruit waste with a 1:0 dilution (E1P0) and 75% higher than eco-enzyme fertilizer from fruit and vegetable waste with a 1:0 dilution (E3P0). The K nutrient content in eco-enzyme fertilizer from vegetable waste with a 1:0 dilution (E2P0) is 30% higher than fruit and vegetable eco-enzyme fertilizer with a 1:0 dilution (E3P0) and 40% higher than fruit eco-enzyme fertilizer with one dilution: 0 (E1P0). Organic nutrient C content in eco-enzyme fertilizer from fruit and vegetable waste with a 1:0 dilution (E3P0) is 37.5% higher than fruit eco-enzyme fertilizer with a 1:0 dilution (E1P0) and 7.27% higher than vegetable eco-enzyme fertilizer with one dilution 1:0 (E2P0). The best ecoenzym fertilizer is E2P0.

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