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The Effect of Eco Enzyme from Pineapple (*Ananas comosus*) Peel Waste on Soil pH, P availability, Growth and Yield of Shallots (*Allium cepa*) in Ultisols

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ABSTRACT

Ultisols have a main problem of high soil acidity, low organic matter, low macronutrients, and very low P availability which can affect plant growth and yield. This research aims to determine the dynamics of soil pH, and P availability and determine the concentration of pineapple peel-based eco enzyme that produces the highest shallots. This research was carried out using a Completely Randomized Design (CRD) with treatment concentrations of eco enzyme 20% (200 mL eco enzyme and 800 mL water), 40% (400 mL eco enzyme and 600 mL water), 60% (600 mL eco enzyme and 400 mL water), 80% (800 mL eco enzyme and 200 mL water), 100% (100% eco enzyme), without treatment/control, and NPK fertilizer treatment. The results showed that the application of eco enzyme at a concentration of 60% was a sufficient concentration to improve soil characteristics and shallot yield as indicated by soil pH of 6.58, soil P of 6.75 ppm, number of bulbs 3.21 and weight of bulbs 4.69 g, as well as the application of 100% eco enzyme to provide soil organic C amounted to 3.76% which was higher than other treatments.

Keywords : *eco enzyme, shallots, Ultisols*

INTRODUCTION

Ultisols are one of the soils found in Indonesia and are spread across several large islands with an area of around 45,794,000 ha or 25% of Indonesia's land area. This type of soil develops in various topographies, from undulating to mountainous with high rainfall. Soil analysis data from various regions shows that Ultisols in Indonesia have grain size classes that vary from fine clay (clay 17-35%) to clay (clay 37-55%), and acid to very acid soil reactions (pH 4.1-4 .8).

The main problems of Ultisols for agricultural cultivation are low pH (< 5), low to very low organic C (0.13% - 1.12%), and low total N (0.09 – 0.18%). The contents of macronutrients such as P, K, Ca, and Mg are low, Al saturation is high, namely > 60% which is toxic to plants, cation exchange capacity (CEC) and base saturation (KB) are low to very low (Prasetyo & Suriadikarta, 2006; Syahputra *et al*., 2015). Therefore, P bound by Al becomes unavailable to plants (Yuniarti, 2020). The generally low organic matter content with varying P and K potential can be concluded that the overall fertility of Ultisols is low (Prasetyo *et al*., 2005). Ultisols acidity, exchangeable-Al (exchangeable aluminum), and iron (Fe) levels can poison plants. The degree of base saturation is low, the cation exchange capacity is low, and the water holding capacity is also low (Heide, 2004). Adding organic matter to the soil can increase soil fertility. Organic matter added to the soil is more efficient for improving soil properties, and especially for increasing nutrients in the soil (Roidah, 2013). Shallots are often cultivated in acidic soils such as Ultisols.

Shallots are considered a strategic commodity because people need them in their daily lives, so they can influence the macroeconomy and high inflation rates. The shallot commodity is also a source of income for farmers and the country's economy as well as a source of employment opportunities that can make a significant contribution to regional economic development (Pakpahan *et al*., 2017). The macronutrients P and K are important for plant growth and development. In shallots, P and K can provide better tuber yield, quality, and longer shelf life of bulbs, and long dense bulbs if stored for a long time. Higher K availability in the soil increases tuber

weight since K plays an important role in translocation and assimilation storage, increasing the size, number, and yield of tubers per plant (Sumarni *et al*., 2013). Increasing onion productivity can be done by adding elements and growth regulators as biocatalysts such as enzymes. Eco enzyme can improve plant growth. The basic ingredients for eco-enzyme preparation can come from various sources, including pineapple peel.

Pineapples from the Bromeliaceae family grow in tropical and subtropical areas, including Indonesia, Malaysia, Thailand, the Philippines, China, Kenya, and India (Martins *et al*., 2014). Pineapples contain sugar, citric acid, malic acid, vitamin A, vitamin B, and a special enzyme, namely the enzyme bromelain (Nuraeni *et al*., 2021). Bromelin has the chemical formula $C_{39}H_{66}N_2O_{29}$, is in the form of a clear white to yellowish amori powder, has a distinctive odor, is soluble in water, insoluble in alcohol, chloroform, and ether, stable at an optimal temperature of 50-60 ^oC and can survive at a temperature of 70 ^oC before inactivation occurs (Nuraeni *et al*., 2021). The bromelain enzyme belongs to the group of glycoproteins, namely proteins that contain one part of an oligosaccharide. The bromelain enzyme is a protease enzyme such as renin (renet), papain, and fisin which has the property of hydrolyzing proteins (Purwasih *et al*., 2021).

Enzymes are biocatalysts that are widely used in various fields of agricultural, chemical, and medical industrial products. Enzymes have specific beneficial properties, namely: efficient, selective, predictable, reaction processes without side products, and environmentally friendly. These properties cause the use of enzymes to increase from year to year. The bromelain enzyme breaks down proteins by breaking peptide bonds and producing simpler proteins (Wuryanti, 2006). Bromelain is a proteolytic enzyme or protease, an enzyme that catalyzes the breakdown of proteins into amino acids by building blocks through hydrolysis reactions. Hydrolysis is the breakdown of large molecules into smaller units with the combination of water. In protein digestion, peptide bonds are broken by the insertion of water components, -H and -OH, at the end of the chain (Maryam, 2009).

Pineapple peel waste contains P 23.63 ppm, K 8.25 ppm, N 1.27%, Ca 27.55 ppm, Mg 137.25 ppm, Na 79.52 ppm, Fe 1.27 ppm, Mn 28.75 ppm, Cu 0.17 ppm, Zn 0.53 ppm and Organic C 3.10% (Susi *et al*., 2018). The nutrients contained in the eco enzyme of pineapple peel play a role in the growth and quality of shallot bulbs. Research conducted by Yuliandewi *et al*. (2018) showed that applying eco enzymes to lettuce had a significant effect on root growth, stem diameter, and plant dry weight. However, in Agus's (2021) research, adding pineapple peel eco enzyme to the growth of shallots had no significant effect. Therefore, it is necessary to apply eco enzymes to the growth and production of shallots, soil pH, and P availability.

MATERIALS AND METHODS

This research was carried out in July-September 2022 in Kandang Limun Village, Muara Bangkahulu District, Bengkulu City. Eco enzyme production was carried out on April 1, 2022. Plant generative variables were measured after harvest. Initial and final soil analyses were carried out at the Soil Science Laboratory, Faculty of Agriculture, Bengkulu University.

This research used a Completely Randomized Design (CRD) with eco enzyme treatment concentrations of 20% (200 mL eco enzyme and 800 mL water), 40% (400 mL eco enzyme and 600 mL water), 60% (600 mL eco enzyme and 400 mL water), 80% (800 mL eco enzyme and 200 mL water), and 100% concentration (100% eco enzyme). The other two treatments were no treatment/control, and NPK fertilizer treatment. The treatment was repeated 5 times. Each experimental unit consisted of 1 polybag so 35 polybags were obtained.

Preparation of eco enzyme used organic waste, molasses, and water in a ratio of 3:1:10. The ingredients consisted of 3 kg of pineapple peel, 1 kg of molasses (brown sugar), and 10 L of water. The ingredients were then put into separate jars (2 jars), then closed tightly, and stored for 3 months. The eco enzyme fermentation process was carried out semi-anaerobically, therefore the jar was opened periodically. During the first month, the jar was opened occasionally to release the gas produced during the fermentation process and after 3 months the eco enzyme was ready for application.

The soil used as a planting medium was taken from Kandang Limun Village, Muarabangkahulu District, Bengkulu City. Soil samples for laboratory analysis were first collected compositely from several points at a depth of 0-20 cm. Analysis of soil physical and chemical properties was carried out at the Soil Science Laboratory, Faculty of Agriculture, Bengkulu University. The soil analyzed was for texture using, organic-C, available-P, and soil pH. Planting media was put into 5 kg polybags on a dry basis. Collected data were analyzed using analysis of variance (ANOVA) and followed by Duncan's Multiple Range Test (DMRT) at the $\alpha = 5\%$ level to compare means between treatments.

RESULTS AND DISCUSSION

Laboratory analysis showed that the soil had a pH of 4.37, organic-C of 2.05%, available P of 4.56 ppm, 35.56% sand, 30.11% clay, and 34.33% silt).

The eco enzyme contained 19,000 ppm N, 29.09 ppm P, 9.38 ppm K, 44,800 ppm C, 25.57 ppm Ca, and 89.51 ppm Mg.

Weather conditions during the study, collected from Pulau Bai Climatogical Station showed that the average rainfall from July to September was 138 mm month^{-1} -188 mm month^{-1}, the average air temperature was 20 ^{o}C- 30 ^{o}C, and the air humidity was 86%-84%. This shallot plant requires maximum sunlight (minimum 70% exposure), air temperature of 25 ^{o}C-32 ^{o}C, and relative humidity of 50-70% (Sutarya & Grubben, 1995). The weather data indicates that the growing conditions for shallots are not optimal for shallot growth due to higher rainfall and a month with lower sunlight intensity than required for optimal growth of shallots.

The Bima variety of shallots is a local shallot from Brebes, suitable in the lowland environment. This shallot has characteristics of cylindrical green leaves with holes, pink tubers with an oval tuber shape, and a small ring on the disc neck. Shallot generally grows in dry climates. Shallot is sensitive to rainfall and high rain intensity, as well as foggy weather.

Effect of eco enzyme on organic C, available P, and soil pH

The application of eco enzyme at the concentration of 100% (E_5) was significant from the NPK treatment and without treatment for the C-organic of the soil (Table 1).

Table 1. The effect of eco enzyme concentration on soil chemical properties

Treatment	% C	P_2O_5 (ppm)	pH
T_1	2.01 d	3.59 d	4.18 b
N_1	2.37 cd	4.88 cd	4.41 b
E_1	2.48 cd	4.72 cd	5.23 a
E_2	2.63 bc	6.55 bc	4.90 a
E_3	2.78 bc	6.74 ab	5.08 a
E_4	3.12 b	7.91 ab	5.01 a
E_5	3.76 a	8.86 a	5.18 a

Note: Numbers in the same column followed by the same letter are not significantly different alpha level 5 % (Duncan Multiple Range Test); T_1 = control; N_1 = NPK fertilizer; E_1 = 20% eco enzyme concentration; E_2 = 40% eco enzyme concentration; E_3 = 60% eco enzyme concentration; E_4 = 80% eco enzyme concentration; E_5 = 80% eco enzyme concentration

The study also showed that P_2O_5 at treatment E_5 (100% eco enzyme) was not significantly different from E_4 (80% eco enzyme) and not significantly different from E_3 (60% eco enzyme), but higher than control and NPK treatment. The treatment E_5 had higher pH than NPK treatment and control but was not significantly different from treatments E_1 (20% eco enzyme), E_2 (40% eco enzyme), E_3 (60% eco enzyme), and E_4 (80% eco enzyme). In addition, organic-C, P_2O_5, and soil pH were not significantly different between the control and NPK treatment. This result is associated with a small dose of NPK, leading to the small contribution of carbon and P to the soil.

Effect of eco enzyme on soil C-Organic

The results of soil analysis show that applying eco enzyme can increase soil C-organic (Table 1). Higher organic-C in soil treated with eco-enzyme might be associated with the addition of organic matter from eco-enzyme and the higher concentration will tend to increase C content in soil. Pineapple peel eco enzyme contains 4.48% organic C, which can increase the organic C in Ultisols. This is in line with research conducted by Susi *et al*. (2018) where the organic C content in pineapple peel eco enzyme is 3.10%. Pineapple peel has alkaloid properties, which help to increase soil fertility. Pineapple peel eco enzyme contains macronutrients (N, P, and K) which are essential for plant growth and development. Also, the enzyme contains Fe, B, Mn, Cu, Zn, and Cl. C-organic content is an important factor as a determinant of soil quality. The higher the total organic C content, the better the soil quality. Soil organic matter plays an important role in improving the physical properties of the soil, increasing soil biological activity, and increasing the availability of nutrients for plants (Siregar, 2017).

Effect of eco enzyme on soil P_2O_5

Soil is a medium for plant growth and provides nutrients for plants. Fertile soils can provide sufficient and balanced nutrients for plants, both macro and micro elements (Pinatih *et al*., 2015). Ultisols have the main problem of high acidity and low content of available P. The application of eco enzyme can improve nutrients as well as available P. Our study shows that the application of eco enzyme increases soil P_2O_5. An increase in P_2O_5 at the application of eco enzyme is related to the addition of this nutrient. The eco enzyme contains 29.09 ppm P. Higher eco enzyme concentration also tends to increase P_2O_5. In addition, the eco enzyme contains organic acids such as humic and fulvic acids which play an important role in binding Al and iron (Fe), releasing P from being fixed by Al and Fe in acid soil.

Effect of eco enzyme on soil pH

Ultisols are generally characterized by acidic soil and low in plant. Nutrients. The application of

eco enzyme increases the pH of Ultisols as shown in Table 2. The pH value of the soil plays a role in determining whether or not nutrients are absorbed by plants. The increase in soil pH due to the application of eco enzyme might be attributed to the formation of Al and humic substance complex, causing lower hydrolysis of Al in soil and raising the pH. According to Spark (2003), humic substances mainly humic and fulvic acids will covalently bond to Al, forming metal complexes in acidic soil, the availability of P is low since. It is bound by Al to form $AlPO_4$.The decomposition of organic matter will be hampered if the soil pH value is too low or too high because the soil pH value affects the work of microorganisms.

The low content of organic material in Ultisols is due to high rainfall and high temperatures in tropical areas. causing intensive weathering and leaching. The climate condition causes alkaline bases to leach, remaining Al and Fe in to soil. High exchangeable Al increases the acidity. The humic and fulvic acid content of eco enzyme will bind Al and reduce its solubility, thereby increasing the pH of Ultisols. Shallot grows best in soil with a pH ranging from 5.5 to 7.0. Soil pH can influence the availability of plant nutrients. Higher pH will increase the growth of shallot (Nisya *et al*., 2019).

Application of eco enzyme for Shallot plant growth

Application of eco enzyme increased growth in shallot plants (Table 2). The 100% eco enzyme concentration treatment was consistently the highest for all variables observed, namely, the number of bulbs, weight of bulbs, and diameter of bulbs except the number of leaves which was not significantly different among treatments.

Table 2. Growth and yield of shallots

Treatment	Number of leaf	Number of bulbs	Weight of bulbs (g)	Diameter of bulbs (mm)
T_1	5.20	4.20 d	26.34 c	13.29
N_1	15.60	5.60 bcd	30.82 bc	16.78
E_1	20.80	6.40 abcd	39.12 bc	16.27
E_2	10.40	5.20 cd	42.20 bc	16.83
E_3	20.00	8.40 ab	62.82 ab	16.96
E_4	16.40	7.60 abc	77.24 a	18.12
E_5	16.40	9.00 a	80.18 a	18.31

Note: Numbers in the same column followed by the same letter are not significantly different alpha level 5 % (Duncan Multiple Range Test); T_1 = control; N_1 = NPK fertilizer; E_1 = 20% eco enzyme concentration; E_2 = 40% eco enzyme concentration; E_3 = 60% eco enzyme concentration; E_4 = 80% eco enzyme con-

Effect of eco enzyme on the number of bulbs

The results showed that the E_5 (100% eco enzyme) treatment produced the highest number of bulbs (9.00) although it was not significantly different from that produced by E_4, E_3, and E_1. The number of red bulbs of the Brebes variety ranges from 7-12 bulbs per cluster (BALITSA, 2018). This is in accordance with research that has been carried out. In the growth of shallots, optimal fertilization can influence the growth of shallot plants. The macronutrients that influence the yield and quality of shallots are N, P, and K. More of these nutrients are needed because plants often experience deficiencies. Therefore, shallots require additional nutrients from outside to be able to grow optimally (Saragih *et al*., 2015).

Based on the results of the analysis of eco enzyme, pineapple skin contains N 1.90%, P 29.09 ppm, K 9.38 ppm which can fulfill the nutrients for the growth of shallots. The P content in the eco enzyme has an important role in energy metabolism. Energy obtained from photosynthesis and carbohydrate metabolism is stored in the form of phosphate compounds which are used for plant growth and reproduction. This P element plays a role in increasing root development so that it can facilitate and accelerate the absorption of soil nutrients. The P element also greatly influences the number of shallot bulbs because P is one of the essential nutrients that plants need for optimum growth and yield (Fatirahma & Kastono, 2020).

Effect of eco enzyme on the weight of bulbs

Fertilization aims to increase soil productivity by providing nutrients for plants, consequently, the productivity of shallot also increases. The application of organic fertilizers such as eco enzymes is a way to enhance nutrient availability in soil. Proper concentration and the application technique of eco enzyme can stimulate roots, encourage plant growth, increase nutrient uptake, and increase the quality and quantity of shallot production. Nutrients in the eco enzyme content from pineapple skin, such as N, can be utilized by plants for the photosynthesis process and to produce photosynthate.

Photosynthesis takes place in leaves and the result of this process in shallot stores in tubers. Increasing the number of leaves will accelerate photosynthesis, consequently, more photosynthates are stored in tubers. This result is in line with that reported by Napitupulu & Winarto (2010) that nutrition encourages vegetative growth and reproduction and, finally, increases the weight of shallot bulbs. Nutrients are

necessary for the photosynthesis process and can increase tuber weight. The results of this study showed that the application of eco enzyme at a concentration of 60% exhibited a higher tuber weight compared to other treatments. Although the diameter of bulbs and number of bulbs were not significantly different in all treatments. This result might be associated with the effective absorption of N, P, and K from the eco enzyme.

CONCLUSION

The application of 60% eco enzyme concentration is a sufficient dose to improve soil characteristics and onion yield indicated by soil pH, soil P, and number and weight of bulbs, and the application of 100% eco enzyme shows an increase in soil C-organic. This study is significant in using an eco enzyme from pineapple peel for the improvement of onion productivity in Ultisols.

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