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RESEARCH ARTICLE
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Chemical Characteristics of Eco-enzymes as Liquid Organic Fertilizer from Vegetable Waste and Its Impact to Improve the Growth of Red Onion (*Allium ascalonicum* L.) on Marginal Dry Land

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ABSTRACT

Applying eco-enzymes and compost to improve plant growth on marginal dry land is an alternative to reducing chemical fertilizers. Moreover, utilizing agricultural waste as a raw material for producing eco-enzymes and compost is crucial for minimizing agricultural waste accumulation, which continues to rise with increasing population and agricultural activities. This research aims to produce eco-enzymes from vegetable waste as liquid organic fertilizer and examine their effect on the growth of red onion. Eco-enzyme production was carried out from July to October 2024, and a field examination of the impact of eco-enzyme on the growth of red onion was carried out from October to December 2024. The study included the chemical characteristics of eco-enzymes, marginal dry land properties (pH, nitrogen, C-Organic, nitrogen-total, phosphorus available, P_2O_5, K_2O, and potassium levels), and red onion plant growth components (plant height, number of leaves, leaves area, and number of shoots Field experiments were conducted to evaluate the effects of eco-enzyme application on the growth of red onion plants using a randomized block design (RBD). The treatment included: control (EK_0), eco-enzyme 15ml/L water + sago pulp compost 10 ton ha^{-1} (EK_1), eco-enzyme 25ml/L water + sago pulp compost 10tonha^{-1} (EK_2), eco-enzyme 15ml/L water + sago pulp compost 15tonha^{-1} (EK_3), eco-enzyme 25ml/L water + sago pulp compost 15tonha^{-1} (EK_4), eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_5), and eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6). Each treatment was repeated five times to obtain 35 experimental units. The study results showed that the nutritional content of eco-enzyme meets the requirements of a liquid organic fertilizer. The research site is classified as marginal dry land. Applying eco-enzyme and sago pulp compost fertilizer positively affects the growth of red onion plants. This study suggests that treating eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6) have significant influences on plant height, number of leaves, leaf area, and shoot development.

Keywords: Eco-enzyme, Sago pulp, Red onion, Vegetable waste, Organic fertilizer.

INTRODUCTION

Population growth significantly impacts the amount of waste produced by society. Waste is the product obtained from a production process by households and industries. According to Arhan et al. (2014), the problem of waste is difficult to solve because it is a cultural or habitual problem that impacts various aspects of life. Hence, the existence of waste requires proper waste management. One type of waste that can be processed for agricultural needs is vegetable waste. Gumilar et al. (2023), stated that one way to reduce the amount of food waste production is by converting the organic waste derived from fruit and vegetables as an ecoenzyme through fermentation. Vegetable and fruit markets, restaurants, and households generate biodegradable wastes, including vegetable and

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fruit peels and waste. Rasit and Mohammad (2018), stated that fruit or vegetable waste use contains organic acids. These organic acid compounds are later converted into an enzyme solution. Eco-enzyme was derived from the fermentation of fresh organic waste, brown sugar, and water that fermented for three months at least (Rasit et al., 2019; Vama and Cherekar, 2020). According to Suwarsono et al. (2023), the fermentation process of eco-enzymes uses the anaerobic method where the air and oxygen cannot contaminate the eco-enzyme mixture during the fermentation process and it is helpful to maintain the benificial bacteria in eco-enzymes. Furthermore, Satrio et al. (2023) explained that the acetic acid (CH_3COOH) content in eco-enzymes can kill germs, viruses, and bacteria. Apart from that, the enzyme content lipase, cellulase, invertase, laccase, xylanase, pectinase, tannase, trypsin, and amylase produced through fermentation can help fertilize land. Apart from that, NO_3- (nitrate ion) and CO_2 (carbon dioxide) are also produced required by the soil as nutrients.

Waste management is required to resist waste accumulation, and it is a systematic, comprehensive, and continuous activity that includes waste reduction and disposal (Karimah and Lusiani, 2024). One of the efforts that can be made to overcome the existence of vegetable waste is to convert this waste into eco-enzymes to produce liquid organic fertilizer through fermentation. Gumilar et al. (2023) stated that the reason for using fruit or vegetable waste is that these organic materials still contain many enzymes that remain active during the eco-enzyme production process. According to Muliarta et al. (2023), the eco-enzyme can certainly become an activator to speed up the composting process. During the fermentation process, carbohydrates are converted into volatile acids and organic acids, glucose is converted to produce pyruvic acid. Pyruvic acid in anaerobic conditions will be decomposed by pyruvate decarboxylase into ethanol and carbon dioxide, where acetobacter bacteria will convert alcohol into acetaldehyde and water which will then be converted into acetic acid (Vama et al., 2020). Another reason for using fruit or vegetable waste is that these organic materials still contain many forms of enzymes that remain active during the eco-enzyme production process (Gumilar et al., 2023). The protein elements from the leftover vegetables will be broken down into nitrogen, which is useful for fertilizing the soil. A study explained that the enzyme content in organic waste in eco-enzymes was enhanced to improve the characteristics of soil contaminated with metals (Muliarta and Darmawan, 2021). In the fermentation process, the acids produced act on the organic material extracting the extracellular enzymes from them (Sai et al., 2023), and organic acid content is the best source to produce eco-enzymes (Benny et al., 2023).

Eco-enzyme is a liquid from the fermentation of natural ingredients that is dark brown with a strong sour aroma. According to Vama and Cherekar (2020), eco-enzyme is a complex solution generated as a product from fermenting fresh kitchen waste, such as vegetable and fruit peels. The fermented eco-enzyme serves multiple functions, including acting as a fertilizer, insecticide, and pesticide. It also helps limit heavy metal accumulation in the soil, increases soil pH by reducing acidity, exhibits antibacterial and antiviral properties, and functions as a plant growth hormone. According to Bungard et al. (1999), organic waste is biodegradable waste that can be degraded or broken down completely through biological processes, both aerobically and anaerobically. Singh et al. (2017), reported that microorganisms and their products, have important role in sustainable agriculture. In addition to providing nutrients, eco-enzymes also produce microbes and microbial products in the form of primary metabolites such as various enzymes, and secondary metabolites, which function as natural pesticides and growth regulators. Research by Muliarta et al. (2023), showed that environmentally friendly enzymes have the potential to become activators that can be used to accelerate the composting process. Brown and Jones (2022), using eco-enzymes accelerates the decomposition of organic material, enhancing soil fertility. To improve the growth of red onion in marginal dry land, the various factors that affect plant growth must be learned before using technological innovation to recommend solutions to dry land productivity problems.

Efforts to improve the performance of eco-enzymes require solid organic fertilizer. Organic fertilizers function in improving soil structure, and soil texture, reducing soil density, and helping sandy soil to retain water, in addition, they can also improve the health of plant roots. This is because organic fertilizers can provide food for microorganisms that keep the soil healthy and balanced. After all, the actions consuming these microorganisms produce nitrogen and phosphorus naturally. Organic materials can help infiltrate rainwater and maintain groundwater during the dry season. In addition, organic materials likewise contain several nutrients that plants extremely need. One of the solid organic materials that can be used to improve soil fertility is sago dregs compost fertilizer. According to research by Wahida and Limbongan (2015), the content of sago dreg is: C-organic 23.1%, Nitrogen 1.73%, Phosphorus 1.3%, and Potassium 1.5%. Meanwhile, the research results of Rachmawati et al. (2020) showed that the nutritional content of sago dregs is: Nitrogen 13.55%, Phosphorus 29.55 mg/100 g, Potassium 5.10 mg/100 g, Calcium 10.97 Cmol (+)/kg, and Magnesium 1.97 Cmol (+)/kg. Maimuna et al. (2014), stated that sago pith waste granule compost and inorganic fertilizers significantly affect soil's physical characteristics, including soil bulk density, soil particle density, soil porosity, soil macropore, mesopore, and micropore. Gerke (2021) soil fertilization with organic fertilizers containing stable organic carbon helps to increase soil organic carbon. Among these fertilizers, rotted farmyard manure, its composts, or composts from other sources may be very efficient. The application of rotted farmyard composts is much more efficient for increasing soil organic carbon levels (Fuentes et al., 2020).

One of the activities that can be done is to study the effect of eco-enzyme and sago dregs and connect it to the soil properties factors that affect the growth and production of crops such as marginal dry land. According to Bariot (2013), the characteristics of marginal dry land i.e.: sand 55.6%, loam 15.7%, clay 28.7%, pH (H_2O) 4.67, C-Organik 1.18%, N-total 0.11%, P_2O_5 16.25mg/100g, K_2O 14.84mg/100g and Al^{3+} 0.37Cmol/kg. Based on the condition of the physical properties of the marginal dry land identified, the soil in this area has low water holding capacity, so the plants will often experience water stress when it rains late or even rains, with the present study indicating that's characteristics of marginal dry land is C-organic 2.26%, N-total 0.57%, P_2O_5 28.98mg/100g, K_2O 23.08mg/100g. According to Sufardi et al. (2022), the problems encountered in sub-optimal dryland farming systems are very complex, because in addition to being caused by low-quality soil characteristics, land management systems are not yet optimal.

The novelty of this research is how to make eco-enzymes whose raw materials are fresh vegetable waste combined with the first rice washing water to increase the nutrient content in eco-enzymes as liquid organic fertilizer. The current study aims to produce eco-enzymes from vegetable waste as liquid organic fertilizer and examine their effect combined with sago dregs on the growth of red onion on marginal dry land.

MATERIALS & METHODS

Research Area: This research was conducted at the Field Laboratory and Agrotechnology Laboratory, Faculty of Agriculture, Halu Oleo University, Kendari Indonesia. Eco-enzyme production was carried out from July to October 2024, and a field examination of the impact of eco-enzyme combined with sago dregs on the growth of red onion was carried out from October to December 2024.

Land Preparation and Soil Sampling: The stages of preparing and managing previous research land by cleaning weeds and plant remains. The land cultivated was done by tractor and hoeing until the soil was loose and, made into plots measuring 1 meter x 1.5 meters and a bed height of 20 cm. Delvi et al. (2019) soil sampling was carried out 1 day before soil processing using a sample ring of 5 points with a diagonal method. The size of the sample ring is 4cm, acute a 7.63cm inner diameter, and a 7.93cm outer diameter, and the tube is covered with plastic at both ends. Intact soil samples were taken at a deepness of 10-20cm from the soil surface. The soil taken at each point is approximately 500g, then taken to the laboratory to be analyzed according to the soil analysis method.

Seed Preparation and Planting: red onion seed preparation is hung and air-dried. The tip of the red onion bulb is cut to facilitate the emergence of roots. Planting in each planting hole is filled with one red onion seed with a planting distance of 20 x 15cm. Watering is done after planting the red onion so that the plants do not wilt and to facilitate the growth of red onion seedlings.

Production of Eco-enzymes: Eco-enzymes are made using agricultural waste from vegetable waste. The vegetable waste used is cabbage and spinach. 1) Prepare materials from cabbage and spinach waste, brown sugar, clean water, and rice washing water; 2) Chop the cabbage and spinach waste using a knife or machete until they become small pieces; 3) Weigh the chopped vegetable waste according to the specified ratio and mix it into a container with a volume of 80L; 4) The ratio commonly used is 1: 3: 10 (Daffa et al., 2024). This study used a ratio of 3: 9: 30, namely 3kg of brown sugar, 9kg of organic material (4.5kg of cabbage waste and 4.5 spinach waste), and 30L of water (29L of clean water + 1L of rice washing water), (Halim et al., 2024). Stir the mixture of ingredients until homogeneous, then close the container isolate the lid in the container tightly, and then store it in a place that is not exposed to direct sunlight; 6) Ensure the container lid is tight and the air inside does not escape. Every 7 days the container must be checked and opened so that the steam inside can escape. The mixture is put in a plastic bucket and fermented anaerobically for three months further stirring is done for the first week and continued once a month for three months (Ginting et al., 2021).

Maintenance: Plant maintenance includes replanting, watering, and controlling plant pests. Replanting is done at the age of 7 days after planting (DAP) to replace plants that do not grow or die. Watering the plants is done every day if it does not rain. Control of plant pests is done manually by directly removing parts of the plant that are attacked by plant pests.

Experimental Design: This study used a randomized block design (RBD) with the following treatments: Control (EK_0), eco-enzyme 15ml/L water + sago dregs compost 10tonha^{-1} (EK_1), eco-enzyme 25ml/L water + sago dregs compost 10tonha^{-1} (EK_2), eco-enzyme 15ml/L water + sago dregs compost 15tonha^{-1} (EK_3), eco-enzyme 25ml/L water + sago dregs compost 15tonha^{-1} (EK_4), eco-enzyme 15ml/L water + sago dregs compost 20tonha^{-1} (EK_5), and eco-enzyme 15ml/L water + sago dregs compost 20tonha^{-1} (EK_6). Each treatment was repeated five times to obtain 35 experimental units.

Observation Variable: Chemical characteristics of eco-enzymes were analyzed in the Biomolecular and Environmental Laboratory of the Faculty of Mathematics and Natural Sciences at Halu Oleo University. Plant growth observations were conducted randomly on five sample plants in each experimental plot. The plant variables observed were: plant height, number of leaves, leaf area, and number of tillers at ages 7, 14, 21, 28, and 35 days after planting (DAP).

Data Analysis: The observation data of plant growth was analyzed using variance if there is a significant difference, then continue with Duncan's Multiple Range Test (DMRT) at a 95% confidence level.

RESULTS

Table 1 showed that the nutrient content in eco-enzymes from vegetable waste has great potential as liquid organic fertilizer. Based on Table 1, it shows that the pH value of eco-enzyme is 3.96. The highest micronutrient content is Ferro at 11.804mg/L, and the lowest is Cuprun at 0.2081mg/L. The highest macronutrient content is Calcium at 40.019mg/L and the lowest is Potassium at 2.64%.

Table 1: Nutrient content of eco-enzymes from vegetable waste as liquid organic fertilizer

No	Nutrient Content	Results	Method
1	pH	3.96	AAS
2	Boron(B)	0.0696mg/L	AAS
3	Ferro(Fe)	11.804mg/L	AAS
4	Mangan(Mn)	4.2290mg/L	AAS
5	Cuprum(Cu)	0.2081mg/L	AAS
6	Zinc(Zn)	1.2526mg/L	AAS
7	Calcium(Ca)	40.019mg/L	AAS
8	Magnesium(Mg)	28.250mg/L	AAS
9	Nitrogen(N)	2.80%	Kjeldahl
10	Phosphorus(P_2O_5)	3.92%	Spectrophotometric
11	Potassium(K_2O)	2.64%	ASS
12	C-Organic	14.30%	Spectrophotometric

Table 2 shows the best average plant height obtained in the treatments of eco-enzyme 15 ml/L water + sago dregs compost 15tonha^{-1} (EK_3) i.e.: 23.46cm which was not significantly different from the EK_1, EK_5, and EK_6 treatments, but significantly different from the EK_2 and EK_4 treatments.

Table 2: The effect of eco-enzyme and sago dregs on the average height of red onion at 35 DAP

Treatments	Plantheight(cm)	DMRT95%
EK_0	18.14c	
EK_1	22.24ab	2=3.24
EK_2	18.91bc	3=3.41
EK_3	24.50a	4=3.50
EK_4	19.82bc	5=3.58
EK_5	21.74ab	6=3.64
EK_6	23.46a	7=3.68

Values followed by different alphabets differ significantly (P<0.05).

Table 3 shows the average number of leaves at 28 DAP, the best treatment was obtained eco-enzyme 15ml/L water + sago dregs compost 10tonha^{-1} (EK_1) i.e.: 19.04 sheet that was not significantly different from treatments EK_2, EK_5, and EK_6, but significantly different from treatments EK_0, EK_3, and EK_4. The best average number of leaves aged 35 DAP was obtained in the treatments eco-enzyme 15ml/L water + sago dregs compost 20tonha^{-1} (EK_6) i.e.: 21.84 sheet which was not significantly different from the EK_1 and EK_5 treatments, but significantly different from the EK_0, EK_2, EK_3, and EK_4 treatments.

Table 3: The effect of eco-enzyme and sago dregs on the average number of leaves of red onion aged 28 and 35 DAP

Treatments	Number of leaves 28 DAP	DRMT 95%	Number of leaves 35 DAP	DRMT 95%
EK_0	11.88c		12.20d	
EK_1	19.04a	2=3.08	20.92ab	2=3.77
EK_2	16.04ab	3=3.24	16.32c	3=3.96
EK_3	14.96bc	4=3.32	16.76c	4=4.07
EK_4	15.08bc	5=3.40	16.96bc	5=4.16
EK_5	16.88ab	6=3.46	18.84abc	6=4.23
EK_6	17.92ab	7=3.49	21.84a	7=4.27

Values followed by different alphabets in a column differ significantly (P<0.05).

Table 4 shows the best average leaf area at 7 DAP was obtained from the treatment eco-enzyme 15ml/L water + sago dregs compost 15tonha^{-1} (EK_3) i.e.: 50.29cm^2 which was not significantly different from the EK_4, EK_5, and EK_6 treatments, but significantly different from the EK_0, EK_1, and EK_2 treatments. The best average leaf area at 14, 28, and 35 DAP was obtained in the treatment eco-enzyme 15ml/L water + sago dregs compost 20tonha^{-1} (EK_6) i.e.: each 116.67cm^2, 372.07cm^2 and 488. 96cm^2.

Table 4: Effect of eco-enzyme and sago dregs on the average leaf area (cm^2) of red onion aged 7-35 days after planting (DAP)

Treatments	DAP 7	14	21	28	35
EK_0	31.51c	83.89b	196.37cd	146.96d	138.45e
EK_1	35.80cd	110.74a	288.10a	370.89a	417.11ab
EK_2	38.53bcd	103.45a	180.22d	296.46bc	294.45d
EK_3	50.29a	108.31a	222.26bc	250.45c	341.36bc
EK_4	44.13abc	106.50a	190.86cd	263.01bc	309.59cd
EK_5	47.15ab	101.30a	212.94c	318.17ab	379.82bc
EK_6	40.83abcd	116.67a	282.05a	372.07a	488.96a
DRMT 95%					
	2=8.64	2=17.63	2=38.10	2=52.72	2=73.73
	3=9.08	3=18.54	3=40.06	3=55.43	3=77.52
	4=9.32	4=19.02	4=41.10	4=56.87	4=79.54
	5=9.53	5=19.44	5=42.01	5=58.14	5=81.31
	6=9.70	6=19.80	6=42.79	6=59.22	6=82.82
	7=9.79	7=19.98	7=43.19	7=59.76	7=83.58

Values followed by different alphabets in a column differ significantly (P<0.05).

Table 5 showed the highest average number of shoots at 7, 14, 21, and 28 DAP in the treatment eco-enzyme 15ml/L water + sago dregs compost 20tonha^{-1} (EK_6) i.e.: 1.92 shoots, 3.48 shoots, 428 shoots, and 5.04 shoots. The highest average number of shoots at 35 DAP was obtained in the treatment eco-enzyme 15ml/L water + sago dregs compost 10tonha^{-1} (EK_1) as 5.60 shoots.

Table 5: The effect of eco-enzyme and sago dregs on the average number of shoots of red onion plants aged 7-35 DAP

Treatments	DAP 7	14	21	28	35
EK_0	1.56b	2.56bc	3.12c	3.92b	3.76c
EK_1	1.52b	3.12ab	4.08a	5.00a	5.60a
EK_2	1.40bc	2.40c	3.72abc	4.28ab	3.88bc
EK_3	1.48bc	2.72bc	3.36bc	4.24ab	4.48abc
EK_4	0.80d	3.00ab	3.96ab	4.72ab	5.32a
EK_5	1.12cd	2.64b	3.92ab	4.60ab	4.96ab
EK_6	1.96a	3.48a	4.28a	5.04a	5.32a
DRMT95%					
	2=0.34	2=0.52	2=0.60	2=0.73	2=1.10
	3=0.36	3=0.55	3=0.63	3=0.77	3=1.16
	4=0.37	4=0.56	4=0.64	4=0.79	4=1.19
	5=0.37	5=0.57	5=0.66	5=0.81	5=1.21
	6=0.38	6=0.59	6=0.67	6=0.82	6=1.24
	7=0.38	7=0.59	7=0.68	7=0.83	7=1.25

Values followed by different alphabets in a column differ significantly (P<0.05).

DISCUSSION

Based on Table 1, the nutrient content in eco-enzyme as a liquid organic fertilizer varies. The potential hydrogen (pH) of eco-enzymes is 3.96 which is included in the sour category. According to Etienne et al. (2013), acetic acid comes from bacterial metabolism found in vegetable and fruit waste, this process is anaerobic metabolism which is bacterial fermentation, namely to obtain energy from sugar which obtains acetic acid and alcohol by-products, so it can be concluded that eco-enzymes have a low pH because they have a high content of organic acids, namely citric acid and acetic acid. The highest micronutrient content is Ferro at 11.804mg/L and the lowest is Cuprun at 0.2081mg/L. The highest macronutrient content is Calcium at 40.019mg/L and the lowest is Potassium at 2.64%.

The study showed that the best average plant height was obtained in the treatment eco-enzyme 15ml/L water + sago pulp compost 15tonha^{-1} (EK_3) as 23.46cm (Table 2). This shows that the provision of eco-enzyme and sago dregs compost has a good effect on the growth of red onion. Fertilization is vital because it determines the level of development and results both quantitatively and qualitatively. The ability to increase height occurs due to cell division, expanding the number of cells, and increasing the size of cells. The increase in height can be associated with the involvement of nitrogen in the process of amino acid synthesis because protein is needed for plant growth. Brown and Jones, (2022), the element nitrogen is a basic cell component and plays an important role in all living tissues of plants. According to Fathi et al. (2016), applying the right amount of nitrogen fertilizer can significantly increase biomass, and also high biomass is only possible under nitrogen fertilization conditions. Gerke (2022), stated that soil organic matter, its stable components (humic substances), and its transient components can strongly improve nutrient availability and acquisition by higher plants. Soil organic matter also strongly affects nutrient storage and its availability in soils. For nitrogen (N) and sulfur (S), and in many soils for P, soil organic matter is the main pool of nutrient storage. In the case of micronutrients, especially iron (Fe) and copper (Cu), and to some extent zinc (Zn), soil organic matter determines the availability of these micronutrients to plants.

Table 3 showed that the best average number of leaves at 28 DAP was obtained in the treatment eco-enzyme 15ml/L water + sago dregs compost 10tonha^{-1} (EK_1) as 19.04 sheet which was not significantly different from the EK_2, EK_5, and EK_6 treatments, but in a significant manner different from the EK_0, EK_3 and EK_4 treatments. The best average number of leaves aged 35 DAP was obtained in the treatments eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6) as 21.84 sheets which was not significantly different from the EK_1 and EK_5 treatments, but in a significant manner different from the EK_0, EK_2, EK_3, and EK_4 treatments. Based on the results of this study, administering eco-enzymes at low doses has had a good effect on the number of leaves in red onion plants. According to Sarminingsih et al. (2023), the highest Nitrogen and Potassium parameters are in eco-enzymes from mixed fruit and vegetable peels. Plants need the element Nitrogen for the formation of leaf blades and areas with high chlorophyll content. Qing et al. (2002), stated that an adequate amount of N taken up in the late stages of plant growth delays the degradation of chlorophyll and protein solutions and prolongs the duration of photosynthesis, increasing the defenses of leaves and preventing leaf senescence. The element nitrogen is useful for the vegetative growth of plants, namely the formation of new cells such as leaves, and branches, and replacing damaged cells. In this study, the content of eco-enzymes from vegetable waste i.e.: nitrogen at 2.80%, potassium at 2.64%, and phosphorus at 3.92% (Table 1).

The number and size of cells largely determine the formation of the number of leaves, and they are also influenced by the nutrients absorbed by the roots that are used as food. In this case, increasing the availability and absorption of nitrogen required by plants can stimulate their vegetative growth. Nitrogen nutrients are needed for the structure of chlorophyll, which is useful in photosynthesis and triggers plant vegetative growth. The frequency of fertilizer application with different doses influences the rare number of leaves. Ciampitti and Vyn (2011), that physiological mechanisms controlling N utilization in plants under different N management practices are crucial to improving N utilization efficiency besides reducing excess fertilizer application while maintaining acceptable yields and environmental quality. The number of leaves and leaf area are closely related to more effective capture of CO_2 light so that the rate of photosynthesis increases and is also related to the formation of shoots and the number of tubers which will affect the fresh weight of the plant and the total dry weight of the plant. The more leaves are produced, the higher the opportunity to fruitage fresh weight and total dry weight of the plant (Elisabeth et al. 2013).

Table 4 showed the best average leaf area at 7 DAP was obtained from the treatment eco-enzyme 15ml/L water + sago pulp compost 15tonha^{-1} (EK_3) as 50.29cm^2 which is not significantly different from the treatment EK_4, EK_5, and EK_6, but in a significant manner different from with the treatment EK_0, EK_1, dan EK_2. The best average leaf area at 14, 28 and 35 DAP was obtained at treatments of eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6) each as 116.67cm^2, 372.07cm^2 and 488.96cm^2. Based on the results of this study, the provision of eco-enzymes and compost fertilizers has a good effect on the leaf area of shallot plants at different plant ages. This happens because leaves are the main organs for absorbing solar radiation and carrying out photosynthesis in plants, so the assimilates produced affect the total dry weight of the plant. Leaf area will increase along with plant development and reach a maximum value at the beginning of the generative period. According to Daffa et al. (2024), the protein elements from the leftover vegetables will be broken down into nitrogen, which is useful for fertilizing the soil. Murtafaqoh and Winarsih (2022), that vegetable waste is rich in nutrients, including nitrogen. The element N has a function for the formation of amino acids, and proteins and the improvement of vegetative growth.

Table 5 shows the highest average number of shoots at 7, 14, 21, and 28 DAP eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6) i.e.: 1.92 shoots, 3.48 shoots, 428 shoots, and 5.04 shoots. The highest average number of springs at 35 DAP was obtained in the treatment of eco-enzyme 15ml/L water + sago pulp compost 10tonha^{-1} (EK_1) as 5.60 shoots. Based on the research results of Arhan et al. (2024) the frequency of giving liquid organic fertilizer affects plant height, leaf area, and fresh weight of plants. Balanced macro and micronutrient content can help improve plant metabolism so that growth reaches optimal levels. The leaf area is closely related to more effective light and CO_2 capture so that the rate of photosynthesis increases and is comparable to the formation of shoots. According to Elisabeth et al. (2013), the more leaves are produced, the higher the opportunity to result in fresh heaviness and total dry weight of plants.

Conclusion

Although the content of macro and microelements in vegetable waste eco-enzymes is still relatively low, it can affect the growth of shallot plants. The provision of eco-enzyme and sago pulp compost fertilizer affects plant height, number of leaves, leaf area, and number of shoots. The treatment of eco-enzyme 15ml/L water + sago pulp compost 20tonha^{-1} (EK_6) influences plant height, number of leaves, leaf area, and number of shoots.

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