Application of Eco-Enzyme Solution as A Multipurpose Liquid Fertilizer to Enhance Performance of Sorghum Varieties

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ABSTRACT

Eco-enzyme, derived from various household wastes such as vegetables, fruits, or fruit peel, is an organic fertilizer rich in essential nutrients for plant growth. Therefore, this study aimed to investigate the impact of eco-enzyme concentrations on the growth and yield of several sorghum cultivars (*Sorghum bicolor* (L.) Moench) in Tanjung Sari, Medan Selayang Subdistrict, Medan from June to September 2021. To achieve this objective, a Randomized Block Design (RBD) comprising 2 factors, namely eco-enzyme concentration (T0:0 mL/L, T1:9.3 mL/L, T2: 18.6 mL/L, and T3: 27.9 mL/L) and sorghum varieties (S1: Super 1, S2: Super 2, S3: Suri 4) was adopted. Eco-enzyme solution consisted of molasses, fruit peels (watermelon, cucumber, and orange), and water. The results showed that the interaction between Suri 4 and a concentration of 27.9 mL/L affected sorghum production. Each eco-enzyme and the varieties affected stem diameter (24.93 mm and 22.66 mm), flowering time (59.19 DAP and 56.00 DAP), as well as wet (631.03 g and 410.20 g) and dry stove weights (315.52 g and 205.10 g). Consequently, the application of eco-enzyme at a concentration of 27.9 mL/L enhances both the growth and yield of sorghum.

Keywords: Eco-enzyme; growth and production; sorghum

INTRODUCTION

Soil quality is reduced due to unsustainable intensive land use, leading to a decrease in productivity. To address this issue, farmers are recommended to adopt various technologies, such as incorporating soil conditioners (Babla et al., 2022). Soil amendments can be classified as organic, biological, or mineral additives depending on the composition (Ali et al., 2014; Mustafa et al., 2022). The use of organic materials, sourced locally or from valuable waste, has gained widespread attention. Additionally, the application of water hyacinths from Rawa Pening area, Asian Village, Ambarawa District, Semarang Regency, Indonesia, as a compost medium holds immense potential, given the annual biomass yield of up to 300 tons per hectare (Sittadewi, 2007).

Various sources of organic matter in the environment, including food waste, can be used as soil amendments. Food is one of the world's largest contributors to world waste, with an estimated quarter to one-third of the products being discarded (FAO, 2013). Addressing this challenge requires the adoption of environmentally friendly technologies at the community

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level. For example, composting organic waste, alongside the application of *Trichoderma harzianum* (IES-103) has proven effective in enhancing compost quality (W. Islam et al., 2021). In 2003, Dr. Rosukon Poompanvong introduced a technology for fermenting food or kitchen waste using 3 main ingredients (sugar, kitchen waste, and water), known as Eco-enzyme (Muliarta & Darmawan, 2021). The solution serves as an enhancer of water quality in polluted water, demonstrating significant improvement in parameters including Total Suspended Solid (TSS) in iron-polluted water, with a reduction rate of 99.9% (Yong et al., 2022). Eco-enzyme is also able to increase plant growth by leveraging the nutritional content derived from the combination of organic materials (Ginting & Mirwandhono, 2021). Based on laboratory results, the organic fertilizer from fruits and vegetables has NPK content and C-organic ranging from 0.09-0.1% and 0.01-2.13%, respectively. However, it is the enzymatic activity that triggers the growth of the plant (Fadlilla et al., 2023).

Sorghum bicolor ((L.) Moench) is a grain crop with significant potential as a source of carbohydrates, food materials, animal feed, and export commodities. Compared to other cereals, sorghum has an edge in terms of environmental tolerance, particularly on dry terrain (Irwan et al., 2005). Additionally, it is rich in nutritious content such as protein (8-12%) and fat (2-6%) (Widowati, 2010), making the crop an attractive option for feed, food, and other business products. In Indonesia, sorghum production remains insufficient to meet demand, with limited study efforts focused on developing new varieties (Indahsari & Wibowo, 2018). Addressing this gap requires a deeper understanding of the genetic characteristics of different sorghum varieties to enhance output. The Indonesian Cereal Research Institute introduced two cultivars of sorghum, namely kawali and numbu, originating from India in 2001, both of which have shown considerable productivity (Ardiyanti et al., 2019). Furthermore, new varieties such as Super 1, Super 2, and Suri 4 are in existence. The different cultivars generally have a set of advantages and cons (Prabawa et al., 2023). The development of sorghum varieties is currently based on enhancing resistance to biotic and abiotic stress as well as improving nutritional content to yield varieties with high resilience and nutrient richness.

This study focused on the use of eco-enzyme in cereal crops, especially sorghum which has not been explored. The primary objective was to determine the ability of eco-enzyme derived from fruits as a source of nutrition for enhancing sorghum growth and yield. This study also obtained the right dose of solution to significantly increase crop growth.

METHODS

Study Area and Design

This study was conducted at 1 Tanjung Sari, Medan Selayang, Medan, North Sumatera, ± 25 meters above sea level (ASL), from June to September 2021. The method applied was factorial randomized block design (RBD), comprising 2 treatment factors, namely sorghum varieties (S1: Super 1, S2: Super 2, S3: Suri 4) and eco-enzyme solution with 3 levels (T0:0 mL/L, T1:9.3 mL/L, T2: 18.6 mL/L, and T3: 27.9 mL/L). Study materials included sorghum varieties (Super 1, Super 2, and Suri 4), fruit peel (pineapple, watermelon, cucumber, tangerine), water, and insecticide for pest control containing Fipronil 50 g/L. The tools used were hoes to form plots and loosen the soil, sprayers, measuring cylinders, analytical scales, calculators, and ovens.

Study plots were measured 0.25 m x 0.1 m, with spacing of 0.05 m and 0.15 m between plots and blocks, respectively. Trenches were dug around the land area at a depth of 0.3 m and a width of 0.5 m. Each plot contained 16 plants, with 4 sample plants in the middle. Planting was conducted by drilling 3 cm with 2 seeds per hole previously soaked in water for 1 hour. Finally, the plant spacing was 0.7 x 0.2 m.

Co-Enzyme Preparation

Production of eco-enzyme fertilizer starts with preparing the fruit and vegetable waste in good shape, followed by cleaning and weighing. The fruit peel was collected and placed in a container along with molasses and water. Each ingredient was mixed in proportions of 1, 3, and 10 parts molasses, organic waste, and water, respectively. The container was kept in anaerobic condition and shielded from the sun. During the first month, the container lid was opened once a day for 15 minutes and agitated to remove the gas.

The fertilizer was ready to use after 3 months of fermentation. The liquid solution was separated from the fruit peel using a sieve. Subsequently, it was diluted with water based on the treatments, namely T0:0 mL/L, T1:9.3 mL/L, T2: 18.6 mL/L, and T3: 27.9 mL/L. Application of eco-enzyme solution occurred 3 times, specifically at 4, 6, and 8 weeks after planting (WAP). Nutrient analysis of the solution was conducted at PT. Socfin Indonesia (SOCFINDO), assessing parameters such as C-organic, N, P, K, pH, and C/N ratio.

Soil Sampling and Analysis

Soil analysis was conducted in the laboratory of SOCFINDO. Surface soil samples were collected from the study area, measuring 12.5 m and 9.5 m. Diagonal samples were taken at 5 points and composited into 1 sample to measure the soil pH, C-organic, N, P, K, and C/N ratio.

The Walkey-Black spectrophotometric was used to determine C-organic amendments in the samples. A composite sample of the compost was dried, mashed, and proceeded at a 0.5 mm sieve. The treatment followed the procedures outlined by Bahadori & Tofighi (2016). Furthermore, the sample was measured using a spectrophotometer at an absorbance of 450 nm. To analyze the total nitrogen, the process followed the procedures of the Kjedahl method, with spectrophotometer determination (Devani et al., 1989). P and K nutritional content analysis was conducted through dry ashing-HNO_3 with a spectrophotometer (Rahayu & Surabaya, 2020) and dry ashing-HCl using AAS (Untuba et al., 2022). Soil pH was measured by the H_2O (1:5) electrometry method (Faria et al., 2023).

Plant Sampling and Analyses

Plant height (cm)

Plant height was measured from the base of the stem to the tip of the longest leaf using tape. The first measurement was conducted 2 weeks after planting at intervals of 1 until 9 WAP or at the end of the vegetative period.

Stem diameter (mm)

Stem diameter was measured at 9 WAP or the end of the vegetative period. The diameter of the stem was determined using a caliper, and each sample plant was measured 5 cm above the base of the stem.

Flowering time (days)

The age of flowering was determined when the flowers of each sample plant appeared. Records were taken daily starting from the first flower appearance until 75% of sorghum plants had flowered.

Yield per plot (g)

Production per plot was calculated by weighing the seeds harvested from each plot after separating and threshing from the panicles and cleaning of dirt.

Wet and dry stover (g)

Stover, comprising the canopy of sorghum plant, was weighed upon harvest after it had been cleared of any adhering dirt, such as soil or sand. Dry stover weight was determined after oven-drying at 70 to 80°C for 2 x 24 hours until a constant weight was achieved.

Wet and dry root eight (g)

Wet root weight was observed by weighing the root of the sorghum plant sample. A total of 10 samples per treatment were assessed. Dry root weight was measured by weighing the root after drying with an oven at 70 to 80 °C for 2 x 24 hours to a constant value.

Statistical Analysis

The study data was analyzed using 2-way ANOVA analysis with IBM Statistic 21 software, while the Duncan Multiple Range Test (DMRT) was performed at the 5% level to analyze the significance.

RESULTS AND DISCUSSION

Soil and Eco-Enzyme Parameters

The nutrition content of eco-enzyme is presented in Table 1. Analysis showed that C/N was 2.23, and the principle of composting was to decrease the ratio to the threshold of mineral absorption by the soil. The C/N ratio of organic fertilizer should be below or equal to 20, thereby facilitating nutrient mobilization to plants (Badan Standardisasi Nasional, 2004). When higher than 25-30, N will become immobilized for the plant as a macronutrient (Brust, 2019; Haynes et al., 2015; Nygaard Sorensen & Thorup-Kristensen, 2011). It is

Table 1. Nutrition content of eco-enzyme and soil analysis

Parameters	Eco-enzyme nutrient	Soil analysis	The national standard for compost	Analytical Method
C-organic	1.32%	0.88%		Walkey and black spectrophotometer
N	0.59%	0.26%	0.40%	Kjedahl with spectrophotometer
P	0.06%	0.10%	0.10%	Dry ashing-HNO_3 with the spectrophotometer
K	1.19%	0.04%	0.20%	Dry ashing-HCl with AAS
pH	4.45	5.10		H_2O (1:5)-Electrometry
Ratio C/N	2.23	3.43		

important to note that eco-enzyme takes approximately 3 months to decompose. Based on Rahmawati & Asriany (2020) and Yusuf (2016), longer composting time results in a lower C/N ratio and c-organic content. The microorganisms used the carbon as a nutrient and energy source, leading to an increase in nitrogen levels.

Eco-enzyme analysis showed an N content of 0.59%, exceeding the standard of 0.40%, and a K (Potassium/K_2O) content of 1.19%, exceeding the standard of 0.20% (Badan Standardisasi Nasional, 2004). However, the P (P_2O_5) concentration was higher at 0.60% compared to the standard of 0.10%. The lower P content in the solid fraction was 6 times higher than the liquid and compared to several materials (waste group). The proportion of labile phosphorus forms in the liquid fraction was significantly larger and made up 80–90% of the entire content (Tuszynska et al., 2021; Xie et al., 2022).

Nitrogen is one of the nutrients that is necessary in the vegetative stage for plant development. It considerably improves the productivity and nutritional value of the crop by engaging a crucial part in the biological and physiological processes. The regulation of shoot branching, flowering, and panicle development by nitrate and amino acids, as well as the regulation of proliferation and elongation by N, all play a role in determining plant structure, primarily in grain crops (Leghari et al., 2016; Luo et al., 2020). Based on the data of N content in eco-enzyme, the amount is adequate for compost nutrients and is expected to enhance the growth and development of sorghum.

Based on the data of eco-enzyme, the pH level was below 5, indicating acidity. Soil acidity and eco-enzyme can influence the growth of sorghum and microbial activity. In several microbial, the acidity will decrease the number of microorganisms. Ye et al. (2022) showed that the application of organic fertilizer over a long period will reduce the pH of soil and increase the number of ammonifying bacteria. This was in line with the study by Li et al. (2019) where *Nitrosospira* functioned in an environment with low ammonia concentrations typical of acidic soil conditions.

Effect of Eco-Enzyme on Sorghum Vegetative Stage

This present study showed that Super 1, Super 2, and Suri 4 had significant differences (p<0.05) in plant height (180.63; 201.41; 169.18 cm), stem diameter

Table 2. The plant height (cm) development based on variety and eco-enzyme concentrations

WAP	Variety	Eco-enzyme concentration (mL/L)				Mean
		0(T0)	9.3(T1)	18.6(T2)	27.9(T3)	
3	S1 (Super - 1)	54.02	53.39	54.03	54.15	53.90^{b}
	S2 (Super -2)	56.33	56.81	57.68	59.37	57.55^{c}
	S3 (Suri - 4)	43.48	44.24	43.23	43.15	43.53^{a}
	Mean	51.28	51.48	51.65	52.22	
5	S1 (Super - 1)	83.08	84.83	84.88	85.83	84.65^{b}
	S2 (Super -2)	104.58	103.23	104.10	106.11	104.50^{c}
	S3 (Suri - 4)	79.65	79.46	81.83	81.37	80.58^{a}
	Mean	89.10	89.17	90.27	91.10	
7	S1 (Super - 1)	118.83	119.53	20.13	20.36	119.71^{b}
	S2 (Super -2)	149.32	149.97	150.96	153.37	150.90^{c}
	S3 (Suri - 4)	110.92	113.53	113.47	112.75	112.67^{a}
	Mean	126.35	127.68	128.19	128.83	
9	S1 (Super - 1)	179.92	181.20	180.02	181.39	180.63^{b}
	S2 (Super -2)	201.06	194.65	204.01	205.94	201.41^{c}
	S3 (Suri - 4)	166.63	171.82	168.77	169.52	169.18^{a}
	Mean	182.54	182.56	184.26	185.62	

Note: Numbers followed by the same notation in the same column group show significant differences according to Duncan's Multiple Range Test (DMRT) at the 5% level.

Table 3. Stem diameter (mm) and flowering time of different eco-enzyme concentrations (mL/L) and sorghum varieties

Variety	Eco-enzyme concentration (mL/L)				Mean
	0(T0)	9.3(T1)	0(T0)	27.9(T3)	
Stem diameter (mm)					
S1 (Super – 1)	20.83	20.79	22.44	23.26	21.83[a]
S2 (Super – 2)	23.72	24.90	26.50	25.03	25.04[b]
S3 (Suri - 4)	21.13	22.18	20.83	26.48	22.66[a]
Mean	21.89[a]	22.63[a]	23.26[ab]	24.93[b]	
Flowering time (days)					
S1 (Super – 1)	58.33	59.08	58.92	59.75	59.02[b]
S2 (Super – 2)	61.08	61.83	62.42	61.75	61.77[c]
S3 (Suri - 4)	55.67	56.08	56.17	56.08	56.00[a]
Mean	58.36[a]	59.00[b]	59.17[b]	59.19[b]	

Note: Numbers followed by the same notation in the same column group show significant differences according to Duncan's Multiple Range Test (DMRT) at the 5% level.

(21.83; 25.04; 22.66 mm), and flowering time (59.02; 6.77;56.00 days) (Table 2 and 3). Compared to all the varieties used, Super 2 was the highest for plant height and stem diameter. Based on sorghum morphology, this variety has compatibility with environmental factors, thereby yielding the best plant height and stem diameter (Direktorat Jenderal Tanaman Pangan Indonesia, 2023). Environmental factors play a crucial role in sorghum growth and yield, as genotype-environment interactions can lead to variations in production under similar treatment conditions (Fardin et al., 2023; van der Bom et al., 2023). Based on the variety description, Super 2 was higher than Super 1 and had longer flowering times than Super 1 and Suri 4 (Direktorat Jenderal Tanaman Pangan, 2023). It is important to note that varieties significantly affect the growth and production of sorghum plants. According to the study conducted on sorghum varieties, Super 2 had the highest plant vegetative growth compared to Super 1 and Suri 4 varieties. However, Suri 4 had the highest production yields compared to Super 1 and Super 2 varieties, as presented in Figure 1.

Eco-enzyme treatment has a significant effect on the stem diameter at an optimum concentration of 27.9 mL/L (K3). This is due to the sufficient availability of N and P at 0.59% and 0.08%, respectively, in the solution, as presented in Table 1. The increase in stem diameter was attributed to enhanced assimilation/photosynthesis processes, where synthesized substances were translocated to meristems to produce new cells. The phenomenon is in line with existing studies indicating that sufficient macro-element (N, P, and K) in meristem tissue trigger cell division, elongation, and enlargement, facilitating cell walls and protoplasm formation (Akhtar et al., 2023; Tariq et al., 2023). Furthermore, previous studies have presented the positive impact of organic matter on plant growth, including height and stem diameter (Kusparwanti et al., 2022; Saputra & Nuraeni, 2023). Eco-enzyme play a role in photosynthesis and plant metabolic reactions. This is in accordance with the results of (Salsabila, 2023) which observed enhanced growth in Pak coy (*Brassica rapa* L.) following eco-enzyme application compared to untreated plants. Leaves, crucial organs for photosynthesis, benefit from eco-enzyme treatment, thereby promoting overall plant growth.

Effect of Eco-Enzyme on Sorghum Generative Stage

Sorghum yields varied significantly across different eco-enzyme treatments and varieties. According to production data, the combination of the Suri 4 variety with an application of 27.9 mL/L eco-enzyme led to a notable increase in production, reaching 4196.2 kg ha^{-1}. Moreover, both wet and dry stover weights showed significant differences with the application of 27.9 mL/L (K3) concentration. This increase in production, attributed to the organic fertilizer and variety interaction, is in line with results from Santoso & Pabendon (2020). Genotypic values demonstrated significant differences across all observed traits, and the interaction between fertilizer and genotypes significantly impacted plant height, internode number, stem diameter, leaf count, plant biomass, and stem biomass.

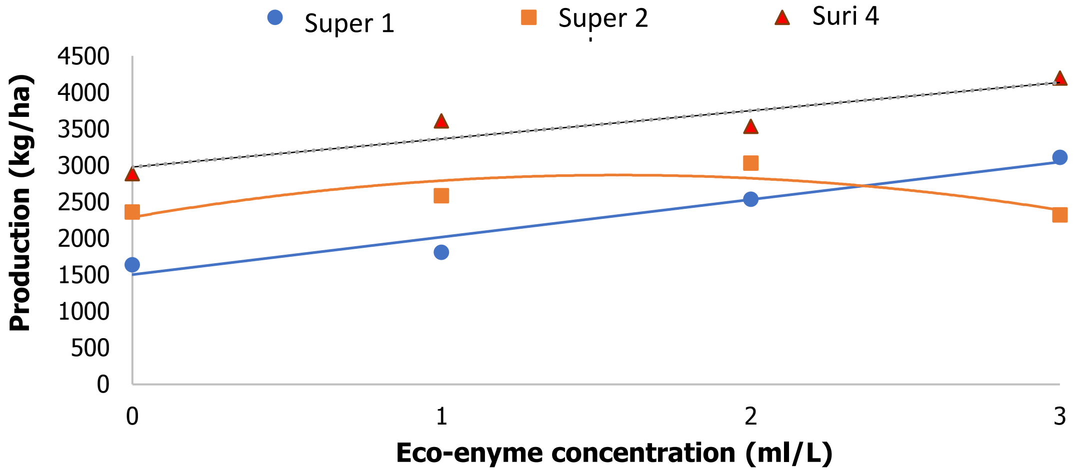

Figure 1. The production of sorghum based on the varieties and eco-enzyme concentration (mL/L)

Table 4. Wet and dry stove weight (g) at different eco-enzyme concentrations (mL/L) and sorghum varieties

Variety	Eco-enzyme concentration (mL/L)				Mean
	0(T0)	9.3(T1)	0(T2)	27.9(T3)	
Wet weight stove (g)					
S1 (Super – 1)	425.59	513.01	567.43	609.61	528.91[b]
S2 (Super-2)	620.28	700.51	728.10	819.83	717.18[c]
S3 (Suri-4)	335.61	407.48	434.03	463.66	410.20[a]
Mean	460.49[a]	540.33[b]	576.52[c]	631.03[d]	
Dry weight stove (g)					
S1 (Super-1)	212.69	239.78	283.70	304.80	260.24[b]
S2 (Super-2)	310.14	350.25	364.05	409.92	358.59[c]
S3 (Suri-4)	167.80	203.74	217.02	231.83	205.10[a]
Mean	230.21[a]	264.59[b]	288.26[c]	315.52[d]	

CONCLUSION

The application of eco-enzyme at a concentration of 27.9 mL/L significantly enhanced the growth of sorghum varieties. Particularly, Suri 4 had promising potential for improved grain production, yielding 4196 kg/ha. The adoption of eco-enzyme derived from household waste presented several environmental benefits, including serving as a nutrient source for agricultural ecosystems.

CONFLICT OF INTEREST

The authors declare no conflict of interest with other parties.

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