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Profitable eco-friendly tomato (*Solanum lycopersicum*) farming through the use of eco-enzymes in Indonesia

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ABSTRACT

Although there is a high demand for tomatoes, supply has not kept up with this demand in Indonesia. Using chemical fertilizers to increase output harms the soil's chemical composition, creating risks for the ecosystem. The use of eco-enzyme, an organic fertilizer, is one substitution option. This study aimed to determine the profitability of tomato farming through the use of eco-enzymes. This study was arranged in a randomized complete block design (RCBD) with three replications (replication as a block). The eco-enzyme dosages consisted of three-levels: 0, 150, and 300 L/ha. Each replication consisted of 6 plants per sample plot. The area of the sample plot was 1.5 m^2. The total cost (TC) and total revenue (TR) were calculated based on all costs and revenues in the sample plot area and then converted to the area per ha. The results showed that using eco-enzyme dosages of 150 and 300 L/ha can increase profits by U$ 114.18/ha (5.3%) and U$ 288.10/ha (13.4%) compared to 0 L/ha (control), respectively. Tomato farming with eco-enzyme doses of 150 and 300 L/ha or control obtained a TR/TC ratio of 2.1. Its means that tomato farming was feasible because TR/TC > 1. The research findings show that using eco-enzymes at dosages of 150 and 300 L/ha can increase the profitability of tomato farming. The future research, we suggest that using eco-enzymes at a dosage higher than 300 L/ha can be applied for profitability in tomato farming.

Key words : Organic fertilizer, production, total cost, total revenue, waste

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important member of the Solanaceae family. It is mainly used globally as a food and commercial crop (Gatahi, 2020) and as one of Indonesia's horticultural commodities with high economic value. The prospects for the development of tomatoes are up-and-coming. The needs of the market from year to year are continuously increasing. The community needs tomato fruit to complement the spices of dishes so that it can be consumed directly in fresh form or juice.

Farmers are interested in tomato production by cultivating new varieties because tomatoes are short-lived and profitable vegetables (Das and Jahan, 2022). High tomato production depends on using superior varieties, better management, and timely provision of inputs (Parvin, 2017; Malik *et al.*, 2022). In Indonesia, tomato production from 2015-2019 increased yearly (Anonymous, 2019). However, chemical fertilizers are often used excessively, increasing production costs and not achieving economic efficiency (El-khalifa *et al.*, 2022). The use of superior varieties and the availability of production facilities will determine the production of tomatoes. However, excessive use of inorganic fertilizers will lead to a deterioration and the environment's physical properties. Therefore, the use of chemical fertilizers should be reduced. One alternative is the use of eco-enzymes.

The production of eco-enzymes has the dual advantage of reducing the burden on organic waste management and is beneficial in agriculture, animal husbandry, household hygiene, etc. (Kerkar and Salvi, 2021). Eco-enzyme results from the fermentation of organic kitchen waste from fruits and vegetables mixed with brown sugar and water. Applying organic substances through eco-enzymes (fermented organic matter) can increase soil and plant productivity (Zulfiqar and Malik, 2017; Srikanth and Reetha, 2021). Therefore, organic matter utilization is one of the environmentally friendly components for plant cultivation. However, how much dosage of eco-enzymes can use to maximize tomato fruit production is still unknown. Therefore, it is necessary to research the use of the optimal eco-enzyme dosage.

Eco-enzymes effectively act as environmentally friendly solutions to reduce the composition of food waste in solid waste landfills and have the potential to be applied to the wastewater industry (Galintin *et al.*, 2021). Waste is the residue or waste from a business or human activity that, if left unchecked, will negatively impact the environment. For example, household waste is commonly found in the skin of fruits and vegetables. But the community does not yet have the awareness to use the waste, even though household waste has the potential to be the basic material for making eco-enzyme. Furthermore, the increasing population increases its activities, producing more waste.

The addition of eco-enzymes increased the availability of nutrients for plants (Nurjaman *et al.*, 2022). The production of liquid organic fertilizers with the main ingredients of agricultural waste significantly affects the content of macronutrients produced (Devianti *et al.*, 2021). Eco-enzymes are made from residues or household waste such as vegetable waste or fruit peels which are widely disposed of by the community. Eco-enzyme in the form of a liquid is dark brown with an intense fruity aroma.

Eco-enzyme is an unexpected composition formed from the fermentation of new kitchen waste, brown sugar, and water (Janarthaan *et al.*, 2020). Eco-enzymes are products produced using raw materials such as peeled fruits and vegetable residues, brown sugar, and water (Kerkar and Salvi, 2021). The eco-enzyme liquid is a product that is easy to use and produce. The manufacture of this product requires only water, sugar as a source of carbon, and organic waste of vegetables and fruits. Eco-enzymes have many benefits, including as a disinfectant and organic fertilizer. According to Eshtiaghi and Nakthong (2020), eco-enzyme can inhibit the growth of microorganisms in wastewater and can treat metal-based effluent.

Eco-enzyme is a liquid fermented from the organic waste of fruits, vegetables, and other organic waste, which is very useful for agriculture (Hasanah *et al.*, 2020). Using eco-enzymes increased dry bulb weight by 20.47 compared to control (Hasanah *et al.*, 2022). Eco-enzymes can provide nutrients and improve soil's physical properties, chemical and biological properties, and product quality. Eco-enzymes significantly affected root length and leaves number at a dosage of 1.75 ml/L of water on shallots (Novianto, 2022).

The provision of eco-enzymes can increase tomato production and is also expected to increase farm income. According to Duhan (2016), Profit analysis compares total costs and revenues. The difference between total revenue and costs is referred to as total profit. Therefore, profit is the total revenue minus the total costs. However, added research results by Mwatawala *et al.* (2019), several factors that affect profitability are farming experience, land area, and access to market information. Furthermore, organizations or groups must be formed to increase profitability among farmers to facilitate the marketing of tomato products.

The total fixed and variable costs constitute the total cost of production per hectare of crop. Operational costs are costs related to the cost of running a farming business (Kushwaha *et al.*, 2018). Fixed costs (FC) refer to costs that do not vary with the production level, while variable costs (VC) refer to those that vary with production. Total costs (TC) are the sum of total fixed costs (TFC) and total variable costs (TVC) (Sekumade and Toluwase, 2014).

The reference study above shows that using eco-enzymes to increase tomato production has not been a concern of previous researchers. In addition, research on the profitability of tomato farming through the use of eco-enzymes has never been done. However, this research can contribute to increasing tomato production to increase the profit of tomato farming. Therefore, this study aimed to determine the profitability of tomato farming through the use of eco-enzymes.

MATERIALS AND METHODS

Study Area

This research was conducted in Soboman Village, Ngestiharjo, Kasihan, District of Bantul, Yogyakarta, Indonesia. The study was conducted in January-June 2022. The tools that were used in this study were hoes, sprayers, and digital scales. In addition, the materials of Corona variety seedlings, NPK Mutiara fertilizer, eco-enzymes, stick bamboo, and pesticides were used in this study.

Experimental Design

This research was conducted in the field and arranged in a randomized complete block design (RCBD) and three replications (replication as a block). The dosage of eco-enzyme consisted of three levels: 0, 150, and 300 L/ha. Each replication consisted of 6 plants per sample plot. The area of the sample plot was 1.5 m^2. The TC and TR were calculated based on all costs and revenues in the sample plot area, then converted to the area per ha.

The TC of production of tomato farming included fixed costs (FC) and variable costs (VC). Fixed costs (FC) were only for land leases. Variable costs (VC) were labor and infrastructure costs. Labor costs included tillage, planting, embroidery, maintenance, weed and disease control, tide, irrigation, and harvesting. The infrastructure cost included seeds, inorganic fertilizers, ajir stake, pesticides, and eco-enzymes. The TR of tomato farming was the multiplication of the price of tomato fruit (P) by the amount of production (Q) at that time.

Profitability of tomato farming through the use of eco-enzymes was calculated using the formula TR/TC ratio.

Research Procedures

This research used regosol soil type. Tillage using a hoe at a depth of 0-20 cm. The soil was loosened, then a sample plot of 1.0 m (width) × 1.5 m (length) or an area of 1.5 m^2 was made, and the soil was left for two weeks. Tomato seedlings were ground at the age of 14 days after sowing. The seeds were obtained from the Trubus store seed provider in Yogyakarta. Planting was carried out by separating the seedlings from the polybags, then planted into the beds at a plant spacing of 0.5 m × 0.5 m. Seedlings were planted on a sample plot with two rows; each row consisted of three plants.

Watering was carried out once every two days every morning. Applying 40 kg/ha NPK was carried out 14 days after planting (DAP). The application of eco-enzymes was performed on tomato plants at 14 DAP with the appropriate treatment dosage. Pest control of the Whitefly was carried out twice during the study using the Curacron pesticide. Locust control was carried out manually.

The first harvesting of tomato fruits was carried out at 60 DAP. The characteristic of the harvested fruit was that 50% of the fruit was red. Then, harvesting was carried out seven times during the study, once every four days.

Observation Variable

In this study, the observed variables include a land lease, labor costs, infrastructure costs, amount of tomato production, TR, and TC.

Statistical Analysis

To calculate the profitability of tomato farming, used a formula of TR/TC ratio. Tomato farming was profitable if the TR/TC > 1. Othewise, If TR/TC < 1, showed that tomato farming was not profitable.

RESULTS AND DISCUSSION

Production Costs

Land lease

Farmed fixed costs were incurred only for land leases (FC). The cost of renting land was US 262.50 per growing season. One growing season was calculated for four months. Tillage until the end of the harvest takes four months. The location of the paddy fields used was technically watered.

Labour Costs

The labor costs of tomato farming included the cost of tillage, planting, embroidery, maintenance, weed and disease control, tide, irrigation, harvesting, etc. In detail, these labor costs can be seen in Table 1.

Table 1 shows that the value of one WDP in this study was U$ 6.56. The highest cost

Table 1. Total labor costs

Labor cost	Dosage of eco-enzyme (L/ha)					
	0		150		300	
	WDP	US$/ha	WDP	US$/ha	WDP	US$/ha
a. Tillage	30	196.88	30	196.88	30	196.88
b. Planting	30	196.88	30	196.88	30	196.88
c. Embroidery	4	26.25	4	26.25	4	26.25
d. Eco-enzym application	0	0	4	26.25	4	26.25
e. Maintenance	4	26.25	4	26.25	4	26.25
f. Weed control	30	196.88	30	196.88	30	196.88
g. Harvest	80	525.00	80	525.00	80	525.00
h. Packing dan transport	16	105.00	16	105.00	16	105.00
i. Stick support	8	52.50	8	52.50	8	52.50
j. Irrigation	6	39.38	6	39.38	6	39.38
k. Pruning water shoots	6	39.38	6	39.38	6	39.38
Total	214	1,404.38	218	1,430.63	218	1,430.63

Remarks: Working day people (WDP), and 1 WDP = U$ 6.56.

was the cost of harvesting, which was carried out for eight harvests, with an average of 80 WDP of each harvest requiring 80 WDP of labor. The highest cost was labor for tillage in the form of stage one plowing, stage two plowing, and the manufacture of beds or sample plots. Other highest labor costs were planting, weed control, packing, and transport. Labor costs included were low: embroidery, maintenance, stick support, watering, and pruning of water shoots. The number of workers in the 0 L/ha was 210 WDP, while with dose treatment of 150 and 300 L/ha, there used 218 WDP. The 150 and 300 L/ha increased working costs of U$ 26,25/ha. According to Samshunnahar *et al.* (2016), human labor and tillage were significant positive variables, which means that various independent inputs effectively contribute to increasing tomato production.

Infrastructure Costs

The infrastructure cost included purchasing seeds, inorganic fertilizers, stick support, pesticides, and eco-enzymes. More details on the cost of facilities and infrastructure can be seen in Tables 2 and 3.

Table 3. Total production costs.

Production costs	Dosage of eco-enzyme (L/ha)		
	0	150	300
Total = 1 + 2 + 3 (US$/ha)	1,968.76	2,142.67	2,290.33

Table 2. Cost of infrastructure.

Labor cost	Dosage of eco-enzyme (L/ha)					
	0		150		300	
	Unit	US$/ha	Unit	US$/ha	Unit	US$/ha
a. Seedlings (stems)	40,000	105.00	40,000	105.00	40,000	105.00
b. Inorganic fertiliser (kg/ha)	40	39.38	40	39.38	40	39.38
c. Eco-enzyme (L/ha)	0	0	150	147.66	300	295.31
d. Stick bamboo (stem)	40000	131.25	40000	131.25	40000	131.25
d. Pesticide (L)	2	26.25	2	26.25	2	26.25
Total costs		301.88		449.53		597.19

Remarks: Price of 1 stem of seedlings @ U$. 0.002625, price of 1 kg of inorganic fertilizer (NPK Mutiara) @ U$. 0.98438, price of 1 L eco-enzyme @ U$. 0.98438, 1 stick bamboo @ U$. 0.003281, and the price of pesticides/ bottles @ U$. 13.125.

Table 2 shows the total cost of facilities and infrastructure at dosages of 0, 150, and 300 L/ha were U$ 301.88/ha, U$ 449.53/ha, and U$ 597.19/ha, respectively. On the other hand, using eco-enzymes at dosages of 150 and 300 L/ha increased costs of U$ 147.66/ha and U$ 295.31/ha, respectively.

Total Production Cost (TC)

Total production costs were the sum of the land rental, labor, and infrastructure. The total production cost is shown in Table 3.

Table 3 shows that the production costs at dosages of 150 and 300 L/ha were due to labor costs for applying and purchasing eco-enzymes. Increasing total production costs at dosages of 150 L/ha was U$ 173.91/ha, while at a dosage of 300 L/ha was U$ 321.56/ha compared to 0 L/ha (control).

Production and Total Revenue

The total revenue (TR) of tomato farming is the multiplication of the price of tomato fruit (P) by the amount of production (Q), which can be shown in Table 4.

Table 4 shows that the lowest total revenue at dosage of 0 L/ha was U$ 4,120.02/ha, the increase in the dosage of 150 L/ha was U$ 4,408.10/ha, and the highest was at the dosage of 300 L/ha provided an income of U$ 4,729.68/ha. According to Naika *et al.* (2019), farmers need to get a higher price for tomatoes than the cost of producing and marketing tomatoes. Engindeniz (2007) adds that farmers should collect economic data on tomato production and market conditions before making production decisions.

Profitability of Tomato Farming

The profit of tomato farming can be calculated from TR – TC. Calculation of farm feasibility using the TR/TC ratio. Tomato farming was profitable and feasible if the TR/TC > 1. The calculation results of TR/TC can be seen in Table 5.

Table 5 shows the lowest profit for tomato farming of U$ 2,170.94/ha occurred in eco-enzyme dosage of 0 L/ha. The dosage of 150 L/ha can increase farm profit by U$ 2,265.43/ha, the highest income obtained in the eco-enzyme dosage of 300 L/ha, which profit was U$ 2,485.29/ha. Using eco-enzymes can increase profits of U$ 114.18/ha (5.3%) for a dosage of 150 L/ha, while at a dosage of 300 L/ha was U$ 288.10/ha (13.4%). The average TR/TC ratio of dosages of 0, 150, and 300 L/ha was 2.1, so it can be said that tomato farming was profitable.

CONCLUSION

Based on the results and discussion, it can be concluded that using eco-enzyme dosages of 150 and 300 L/ha can increase profits by U$ 114.18/ha (5.3%) and U$ 288.10/

Table 4. Production and gross income.

	Dosage of eco-enzyme (L/ha)		
	0	150	300
1. Tomato production (kg/ha)	7,847.60	8,396.33	9,008.87
2. Price (US$kg)	0.53	0.53	0.53
Total gross revenue (US$/ha)	4,120.02	4,408.10	4,729.69

Tabel 5. Profitability and feasibility of tomato farming

	Dosage of eco-enzyme (L/ha)		
	0	150	300
1. Total revenue (US$/ha)	4,120	4,408	4,729.68
2. Total production costs (US$/ha)	1,949	2,097	2,244.39
Total profit (US$/ha)	2,151	2,265	2,439.36
Profitability (US$/ha)	0	114.18	288.10
Feasibility	2.1	2.1	2.1

ha (13.4%) compared to 0 L/ha (control), respectively. Tomato farming with eco-enzyme dosage of 150 and 300 L/ha or control obtained a TR/TC ratio of 2.1. Its means that tomato farming is feasible because TR/TC > 1. Therefore, the study findings show that using eco-enzymes at dosages of 150 and 300 L/ha can increase the profitability of tomato farming. The future research, we suggest that using eco-enzymes at a dosage higher than 300 L/ha can be applied for profitability in tomato farming.

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