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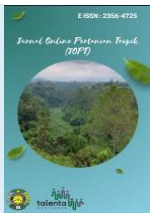

Effectiveness of eco-enzyme in suppressing the growth of *Fusarium* sp. on Shallot Plants (*Allium cepa*) in vivo

Fitria Sukma, Alfizar, Siti Shofiya Nasution, Muhammad Sayuthi, Hartati Oktarina*

Program Study of Plant Protection, Faculty of Agriculture, Universitas Syiah Kuala
*Corresponding Author: oktarina.hartati@usk.ac.id

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ABSTRACT

Shallots (Allium ascalonicum L.) are a high-value horticultural commodity in Indonesia, but production often declines due to Fusarium sp., which cause yield losses of up to 80%. Control using synthetic chemical fungicides remains the primary choice for farmers, demanding environmentally friendly alternatives. This study tested the effectiveness of fruit peel eco-enzymes to control of Fusarium sp. in shallot plants. Five levels of eco-enzymes (0, 0.2, 0.6, and 1%) were applied before and after shallot planting. The results showed that eco-enzymes were able to delay the incubation period, reduce disease severity by 30%, and increase the number and weight of bulbs. It can be concluded that eco-enzymes are effective in controlling Fusarium sp., in shallot plants.

Keywords: *alternative control, fruit peel eco-enzymes, Fusarium* sp*, moler disease, plant protection*

ABSTRAK

Bawang merah (*Allium ascalonicum L.*) merupakan komoditas hortikultura bernilai tinggi di Indonesia, namun produksinya sering menurun akibat penyakit moler yang disebabkan oleh *Fusarium* sp. yang dapat menyebabkan kehilangan hasil hingga 80%. Pengendalian dengan menggunakan fungisida kimia sintetik masih menjadi pilihan utama petani sehingga diperlukan alternatif pengendalian yang ramah lingkungan. Penelitian ini menguji efektivitas ekoenzim berbahan kulit buah untuk mengendalikan *Fusarium* sp. pada tanaman bawang merah secara *in vivo.* Lima level ekoenzim (0, 0,2, 0,6, dan 1%) diaplikasikan sebelum dan setelah penanaman bawang merah. Hasil pengamatan menunjukkan bahwa ekoenzim mampu memperlambat masa inkubasi, menurunkan keparahan penyakit sebesar 30% serta meningkatkan jumlah dan bobot umbi. Dapat disimpulkan bahwa ekoenzim efektif dalam mengendalikan *Fusarium* sp. penyebab penyait moler pada tanaman bawang merah.

Kata kunci: alternatif pengendalian, ekoenzim kulit buah, *Fusarium* sp., penyakit moler, perlindungan tanaman

1. Introduction

Shallots are a horticultural crop with numerous benefits and high economic value in Indonesia (Izzulsyah, 2023). Based on data from the Central Bureau of Statistics (BPS) of Aceh in 2023, shallot production reached 13.672.62 tons. However, in 2024 production decreased by 498.22 tons. This decline may be caused by several factors, one of which is the attack of the fungus *Fusarium* sp.

Fusarium sp. is a pathogenic fungus that causes moler disease in shallot plants (Aprilia and Aini, 2022). Infected plants show symptoms such as yellowing leaves starting from the lower edges and spreading to the middle, as well as twisted leaves. In addition, roots appear brownish, pale, and rotten, while bulbs undergo decay starting from the base and spreading upward and sideways (Irfandri *et al*. 2025). Infection by *Fusarium* sp. can cause losses of up to 80% if not properly controlled (Miftahur and Wahyuni, 2022). Therefore, moler disease requires serious attention, making control efforts very important.

Control of fungal diseases is generally carried out using fungicides. However, continuous use of fungicides can lead to various problems, such as residues that disrupt environmental balance, pathogen resistance, and soil and water pollution due to accumulation of active compounds (Suganda and Widiastuti, 2025). Therefore, more environmentally friendly control alternatives are needed, one of which is the use of eco-enzymes.

Eco-enzymes were first introduced in Thailand by Dr. Rosukan Poompanvong, an organic agriculture expert who has studied enzymes for more than 30 years (Megah, 2018). Eco-enzyme is a dark brown liquid resulting from the fermentation of a mixture of water, fruit and vegetable waste, and palm sugar in a ratio of 10:3:1. Its production process is relatively simple and does not require large land areas, making it suitable for household-scale production. Eco-enzymes are useful as environmentally friendly plant disease control agents and help maintain environmental quality by neutralizing various pollutants (Kriswantoro *et al*., 2022). Eco-enzymes contain various compounds and enzymes such as acetic acid, lipase, amylase, trypsin, nitrate, and bioactive compounds including organic acids, flavonoids, saponins, tannins, and hydrolytic enzymes. These compounds play a role in suppressing pathogenic fungi, including *Fusarium oxysporum*, by lowering environmental pH and disrupting fungal cell membrane function (Istikomah, 2015; Sharfina and Fevria, 2022).

According to Anggita *et al*. (2024), eco-enzymes made from organic waste such as carrots, mustard greens, orange peels, pineapple peels, spinach, watermelon, and melon mixed with molasses and water (3:1:10 ratio) at a 0.5% application rate can suppress moler disease development in shallots by 58%. Karlita (2023) reported that fruit peel-based eco-enzymes contain higher levels of secondary metabolites and enzymes compared to vegetable-based eco-enzymes, making them potentially more effective in suppressing plant pathogens. Therefore, this study evaluates the effectiveness of eco-enzymes derived from various fruit peels such as pineapple, papaya, orange, cucumber, and watermelon in controlling *Fusarium* sp. on shallot plants in vivo.

2. Method

2.1 Location and time

This study was conducted at the Plant Disease Laboratory and greenhouse of the Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh. The research was carried out from November 2025 to January 2026.

2.2 Tools and material

The tools used included an autoclave, laminar air flow cabinet, analytical balance, vortex, microscope, Bunsen burner, tweezers, Erlenmeyer flask, corn borer, scalpel, sprayer, stirring rod, and dropper pipette. Materials included petri dishes, *Fusarium* sp. isolates from the Plant Disease Laboratory collection, fruit peels (pineapple, papaya, orange, cucumber, and watermelon), shallot seeds (F1 Bima Brebes variety), palm sugar, distilled water, Potato Dextrose Agar (PDA), 70% alcohol, chloramphenicol, aluminium foil, plastic wrap, labels, tissue, plastic bags, rubber bands, polybags (25 × 25 cm), bottles, soil, rice husk, and compost.

2.3 Experimental design

This study used a Completely Randomized Design (CRD) consisting of 4 eco-enzyme concentration treatments with 5 replications. The concentration levels of eco-enzyme shown in Table 1.

Tab1e 1. Eco-enzyme concentration levels to control *Fusarium* sp. on shallots

Treatments code	Eco-enzyme concentration (%)
P0	0
P1	0,2
P2	0,6
P3	1

2.4 Research preparation

2.4.1 Eco-enzyme preparation

Fruit peel waste (pineapple, papaya, orange, cucumber, and watermelon) was cut into ±1 cm piece. Each type (60 g) was mixed with 100 g palm sugar and 1 L water in a plastic bottle. The bottle was tightly closed and fermented for 3 months. During the first month, the bottle was opened daily to release gas. In the second and third months, the bottle remained closed. After fermentation, the solution was filtered to obtain the eco-enzyme.

2.4.2 Preparation of Fusarium sp. *suspension*
The fungus was cultured on PDA medium. PDA was prepared by dissolving 10 g powder in 250 mL distilled water and sterilized at 121°C for 30 minutes. Chloramphenicol (0.17 g) was added to prevent bacterial contamination. The fungus was incubated for 7 days.

Mycelia were harvested by pouring 1 mL sterile water onto isolate. Mycelia was scrapped and transferred to fresh reaction tube followed by adding 9 mL of sterile aquades. One mL of suspension at 1×10^6 was dropped onto haemocytometer and observed under microscope. Spore density was calculated using a haemocytometer following Gabriel and Riyanto (1989) as below:

$$S = \frac{X}{L \times t \times d} \times V$$

Keterangan:
S : Spore density
X : The number of spora at each observed square (a,b,c,d,e)
L : Square wide (0,4mm^2)
t : Square depth (0,1mm)
d : Dilution factor
V : Volume of suspense (1 mL = 10^3 mm^2)

2.4.3 Growing media preparation
The planting medium used was a mixture of soil, rice husk, and compost in a ratio of 2:1:1. The soil was first sieved using a 2-mesh sieve, then air-dried by placing the growing medium in a shaded area (not exposed to direct sunlight) for 7 days until the medium became sufficiently and not overly moist. This step aimed to reduce moisture content, improve soil aeration, and suppress the initial growth of soil-borne pathogens (Djatnika *et al*. 2014). Polybags measuring 25 cm × 25 cm with a capacity of 5 kg were filled with 80% of the growing medium, then arranged at a spacing of 20 cm × 20 cm to ensure uniform growth conditions and facilitate plant maintenance.

2.4.4 Planting of shallots
Planting was carried out after the growing medium was ready for use. Uniform shallot bulbs of the Bima Brebes variety were selected as planting material, with criteria including a size of 1.8–2.5 cm, healthy condition, and no excessive sprouting. Bulbs were considered not excessively sprouted if they had only one to two short shoots (<1 cm) at the tip to maintain uniformity (Basuki *et al*. 2014). Before planting, the tip of each bulb was cut approximately 0.5–1 cm to accelerate sprouting (Djatnika *et al*. 2014). The bulbs were planted at a depth of 3 cm with the shoots facing upward to ensure optimal growth (Sutanto and Semiarti, 2019). Each polybag was filled with one bulb, and reserve bulbs were prepared. The polybags were then arranged according to the experimental design with a spacing of 30 cm × 30 cm to facilitate maintenance and reduce excess humidity. After planting, watering was carried out until field capacity was reached, and the polybags were placed in an open area with full sunlight exposure.

2.4.5 Inoculation of Fusarium sp. on shallot plants
Inoculation of *Fusarium* sp. on shallot plants was carried out using the soil drenching method, which involves pouring a spore suspension around the plant roots to ensure that the inoculum enters through the root system (Sarma *et al*. 2025). This method is effective in inducing typical symptoms of wilt or basal bulb rot depending on the virulence level of the *Fusarium* sp. isolate used (Aydi *et al*. 2020). The *Fusarium* sp. isolate was first cultured on PDA medium for 7 days, after which the spores were suspended in sterile distilled water to reach a concentration of 1×10^6 conidia/mL. Spore density was determined using a haemocytometer (Nirmaladevi *et al*. 2016). Inoculation was performed on shallot plants at 7 days after planting (DAP) by applying 2 mL of the suspension around the rhizosphere of each plant. After inoculation, the plants were maintained under moist conditions through regular watering to support the development of pathogen infection (Dissanayake *et al*. 2022; Stankovic *et al*. 2021).

2.4.6 Plant Maintenance
Plant maintenance of shallots in this study included watering, replanting (gap filling), weeding, and control of plant pests and diseases (excluding *Fusarium* sp.) if any infestation was observed. Watering was carried out every morning or afternoon depending on the moisture condition of the growing medium, with the aim of maintaining optimal water availability for plant growth (Rahman *et al*. 2020). Weeding was performed

manually by removing weeds growing around the plants to prevent competition for nutrients, light, and water (Prayoga *et al*. 2021).

2.5 Observed Variables

2.5.1 Incubation period

The incubation period was observed in all plants, starting from the first day of pathogen inoculation until the appearance of initial symptoms of moler disease, indicated by yellowing of the leaves. In this study, observations were conducted up to the 7th day.

2.5.2 Disease incidence

Disease incidence was observed at 14, 21, 28, 35, and 42 days after planting (DAP) by counting the number of plants showing symptoms of *Fusarium* sp. infection. Observations were conducted on all treated plants. The data obtained were calculated using the following formula (Rahardjo and Suhardi, 2008).

$$K = \frac{n}{N} \times 100\%$$

Where:
K : Disease incidence
n : The number of infected plant
N : The number of total plant observed

2.5.3 Diseases severity

Disease severity was observed at 14, 21, 28, 35, and 42 days after planting (DAP) using a symptom scoring system categorized into scores 1–4 (Monika et al., 2025). The symptom scores for moler disease caused by Fusarium sp. are presented in Table 2.

Table 2. Severity score of moler disease in shallot plants

Severity score	Description
 1	The plant still appears green, but slight yellowing and wilting of the lower leaves have begun to appear. *Fusarium* sp. infection is still at an early stage, and the plant can still grow, although its growth is somewhat inhibited.
 2	The symptoms are more pronounced; the leaves show increased yellowing, partial wilting occurs, and plant growth becomes abnormal. The plant is still standing but has begun to exhibit typical symptoms of moler disease.
 3	Severe symptoms are observed, with most leaves turning yellow, wilting, and curling. The plant begins to collapse, growth stops, and the bulbs fail to develop optimally.

Table 2. (Continued)

Severity score	Description
 4	Very severe symptoms are observed; the plant dies or becomes almost completely dry, leaving only remnants of bulbs or decaying plant tissue, and the plant is no longer productive.

Disease severity was assessed by evaluating the level of infection on plant leaves using a symptom scale. The assessment was based on the percentage of plant area showing symptoms of infection, and was then calculated using the formula according to McKinney (1923) and Nuryani *et al*. (2019) as follows:

$$KP = \frac{\sum(ni \times vi)}{Z \times N} \times 100\%$$

Where :

KP : Disease severity
ni : Number of leaves in the i-th infection category
vi : Score value of the i-th infection category
Z : Highest score on the assessment scale
N : Number of plants observed

2.5.4 Number of bulbs and bulb weight

The number of bulbs was observed at harvest, which was at 60 days after planting (DAP), by counting the total number of bulbs per plant for each treatment. The data on bulb number were expressed in units (bulbs) per plant. This parameter was used to determine the effect of treatments on shallot yield. Bulb weight was determined by weighing the total weight of bulbs per plant. Weighing was carried out using an analytical balance to obtain precise results, and the data were presented in g/plant. This parameter was used to evaluate the effect of eco-enzyme treatments on the number and weight of shallot bulbs.

2.6 Data analysis

All observation data were analyzed using ANOVA (Analysis of Variance). If the F-test results showed a significant difference in the calculated F value (F calculated), further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level, using Microsoft Excel 2019.

3. Results and Discussion

3.1 Incubation period of moler disease

The incubation period of a disease is the time interval between inoculation and the first appearance of symptoms on the plant. Several concentrations of eco-enzyme were tested for their effect on the incubation period of moler disease in shallots. A shorter incubation period indicates that the plant is infected more quickly. Conversely, a longer incubation period indicates that the eco-enzyme is more effective in inhibiting pathogen development and delaying the disease symptoms in the plant. The average incubation period of moler disease is presented in Table 3.

Table 3. The effect of various levels of eco-enzyme on incubation period of moler disease on shallot plants

Eco-enzyme concentration (%)	Incubation period (day)
0	3.0 [a]
0.2	4.0 [b]
0.6	4.6 [b]
1	7.0 [c]

Note: Values followed by the same letter within the same column are not significantly different based on the DMRT test at the 5% significance level.

Based on Table 3, it is known that increasing eco-enzyme concentration affects the length of the incubation period of moler disease. The treatment without eco-enzyme (0%) showed the shortest incubation period, which was 3 days, while the application of eco-enzyme at concentrations of 0.2%, 0.6%, and 1% significantly extended the incubation period to 4.0, 4.6, and 7 days, respectively. These results indicate that without eco-enzyme, the pathogen develops optimally, whereas a concentration of 1% provides the most effective inhibition of fungal development. In general, increasing eco-enzyme concentration is associated with an increased ability to delay the appearance of disease symptoms. This finding is consistent with Asni *et al*. (2023), who reported that higher eco-enzyme concentrations result in greater inhibition of the growth of *Fusarium* sp. and *Colletotrichum* sp. fungal colonies.

The incubation period of the moler disease pathogen in shallot plants was observed after inoculation with Fusarium sp. until the plants exhibited initial symptoms. Initially, infected plants showed yellowing and twisting of the leaves, as well as bulb rot. The symptoms of infection can be seen in Figure 1.

Figure 1. Symptoms of moler disease caused by *Fusarium* sp. in the field: (a) twisted leaves, (b) yellowing leaves, (c) bulb rot

3.2 Disease Incidence

The observation results showed that the percentage of moler disease incidence caused by *Fusarium* sp. in shallot plants varied among treatments, indicating differences in plant responses to the applied treatments. In this study, the percentage of disease incidence in shallot plants in the field was observed at 14 and 21 days after planting (DAP). The percentages for each treatment are presented in Table 4.

Table 4. Percentage of moler disease incidence caused by *Fusarium* sp. in shallots under field conditions

Eco-enzyme concentration (%)	Disease incidence (%)	
	14 DAP	21 DAP
0	100.00[b]	100.00[a]
0.2	100.00[b]	100.00[a]
0.6	20.00 [a]	100.00[a]
1	20.00[a]	100.00[a]

Note: Values followed by the same letter within the same column are not significantly different based on the DMRT test at the 5% significance level.

Table 4 shows that at 14 days after planting (DAP), the percentage of moler disease incidence in the 0.2% eco-enzyme treatment was not significantly different from the control. Meanwhile, eco-enzyme treatments at concentrations of 0.6% and 1% showed lower disease incidence percentages, each at 20%. At 21 DAP, all treatments, both control and eco-enzyme, showed the same disease incidence percentage of 100%. This indicates that the increase in disease incidence in the 0.6% and 1% eco-enzyme treatments occurred between 14 and 21 DAP, so that the differences observed earlier were no longer evident at the end of the observation period. This condition is suspected to be influenced by environmental factors, particularly high rainfall during the study, which increased soil moisture and supported the development of *Fusarium* sp. In addition, the bioactive compounds produced during the fermentation process are likely susceptible to degradation due to biological activity, photodegradation, chemical reactions, and movement influenced by abiotic factors such as rainwater and sunlight exposure (Dono and Rismanto, 2008).

3.3 Disease severity

Observation of moler disease severity caused by *Fusarium* sp. in shallot plants under field conditions was conducted every 7 days after pathogen inoculation. Moler disease symptoms appeared at 13 days after inoculation (DAI), and severity was assessed by scoring each infected leaf to obtain the percentage of disease severity. The results of the observation of moler disease severity in shallots are presented in Table 5.

Table 5. Percentage of moler disease severity caused by *Fusarium* sp. in shallots

Eco-enzyme concentration (%)	Disease severity (%)				
	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
0	6.40[a]	25.00[b]	44.00[b]	53.80[c]	59.00[b]
0.2	3.00[a]	18.10[b]	33.50[b]	43.50[b]	49.40[b]
0.6	0.60[a]	8.04[a]	15.00[a]	24.60[a]	29.60[a]
1	5.00[a]	14.00[a]	18.00[a]	26.00[a]	30.00[a]

Note: Values followed by the same letter within the same column are not significantly different based on the DMRT test at the 5% significance level.

Based on Table 5, it can be seen that the percentage of moler disease severity in all treatments tended to increase with plant age at each observation time. At 14 days after planting (DAP), all treatments showed relatively low severity levels and were not significantly different statistically. Differences among treatments began to appear at 21 DAP, where the treatment without eco-enzyme (0%) showed the highest level of severity at all observation times and continued to increase up to 59.00% at 42 DAP. Better disease suppression was observed in the eco-enzyme treatments at concentrations of 0.6% and 1% starting from 21 DAP. In general, increasing eco-enzyme concentration tended to reduce the percentage of disease severity, especially during observations from 21 to 42 DAP. The results showed that eco-enzyme application had a highly significant effect on suppressing moler disease, with the highest effectiveness at a concentration of 0.6% (49.83%), followed by 1% with a suppression rate of 49.15%.

3.4 Number of bulbs and bulb weight

In this study, the effect of eco-enzyme on the number of bulbs and bulb weight was also observed. The number of shallot bulbs under different eco-enzyme concentration treatments (0%, 0.2%, 0.6%, and 1%) is presented in Table 6.

Table 6. The effect of various eco-enzyme concentration on the number of shallot bulb

Eco-enzyme concentration (%)	Number of bulbs (bulbs plant^{-1})
0	4.00[a]
0.2	7.20[a]
0.6	9.00[a]
1	11.40[a]

Note: Values followed by the same letter within the same column are not significantly different based on the DMRT test at the 5% significance level.

Based on Table 6, it is known that higher eco-enzyme concentrations tend to increase the number of shallot bulbs. The application of eco-enzyme helps plants obtain a supply of nitrogen, which plays a role in accelerating protein formation and supporting cell division, elongation, and root enlargement processes (Widarawati *et al*. 2023). A deficiency of nutrients can inhibit root growth due to decreased auxin activity, which is essential for root development (Maryam *et al*. 2015). Plants that receive sufficient nitrogen will develop leaves with larger surface areas and higher chlorophyll content, enabling them to produce more assimilates to support vegetative growth (Dondui *et al*. 2023).

In contrast to its effect on the number of bulbs, eco-enzyme also had a significant impact on shallot bulb weight. The average bulb weight under different eco-enzyme concentration treatments is presented in Table 7. The highest bulb weight was observed in the eco-enzyme treatment at a concentration of 1%, which was 44.49 g plant^{-1}. In contrast, the lowest bulb weight was found in the 0% treatment, which was 6.60 g plant^{-1}, followed by the 0.2% concentration at 27.33 g plant^{-1}, and the 0.6% concentration at 38.90 g plant^{-1}. This is consistent with the findings of Firnawati *et al.* (2025), who reported that increasing eco-enzyme concentration leads to an increase in shallot bulb weight. Widyastuti and Hendarto (2018) stated that the resulting weight is derived from the accumulation of photosynthates produced during plant growth; therefore, higher metabolic activity results in greater plant weight.

Table 7. The effect of various eco-enzyme concentration on the weight of shallot bulb

Eco-enzyme concentration (%)	Bulbs weight (g plant^{-1})
0	6.60^{a}
0.2	27.33^{b}
0.6	38.90^{c}
1	44.49^{c}

Note: Values followed by the same letter within the same column are not significantly different based on the DMRT test at the 5% significance level.

4. Conclusion

Eco-enzyme formulated from fruit peels of orange, pineapple, cucumber, papaya, and watermelon has been proven effective in suppressing the growth of Fusarium sp. in shallot plants in vivo. The application of eco-enzyme at a concentration of 1% showed the highest effectiveness, as indicated by the longest disease incubation period and a more pronounced reduction in disease severity percentage over time, with a disease suppression rate reaching 49.15%. These results indicate that eco-enzyme has high effectiveness in controlling moler disease in shallot plants. In addition to its role in disease control, the application of eco-enzyme also contributes positively to improving the growth and yield of shallot plants.

References

Aprilia, A.D., & Aini, L.Q. (2022). Pengujian konsorsium bakteri antagonis untuk mengendalikan penyakit layu fusarium pada tanaman bawang merah (*Allium ascalonicum* L.) di Kecamatan Dampit, Kabupaten Malang. Jurnal HPT (Hama Penyakit Tumbuhan), 10(1), pp. 29 – 38.

Asni, B., Lubis, S.S. & Harahap, D. (2023). Ekoenzim sebagai pengendalian patogen *Fusarium* sp. dan *Colletotrichum* sp. pada tanaman pisang barangan (*Musa acuminata*). Journal of Biological Sciences and Applied Biology*,* 3(1), pp. 8–14.

Aydi-Ben-Abdallah, R., Jabnoun-Khiareddine, H. & Daami-Remadi, M. (2020). *Fusarium* wilt biocontrol and tomato growth stimulation using endophytic bacteria naturally associated with *Solanum sodomaeum* and *S. Bonariense* Plants. Egyptian Journal of Biological Pest Control*,* 30(1), p.113.

Basuki, R. S., Khariyatun, N., & Luthfy. (2014). Evaluasi dan preferensi petani brebes terhadap atribut kualitas varietas unggul bawang merah. Jurnal Hortikultura*,* 24(3), pp. 276–282.

Dissanayake, R. K., Kashyap, P. L., Kumar, S., and Srivastava, A. K. (2022). *Fusarium* basal rot of onion: Biology, epidemiology and management. Frontiers in Microbiology, 13, 897321.

Djatnika, I., Ginting, C., & Hilman, Y. (2014). Teknologi budidaya bawang merah untuk meningkatkan produktivitas. Jurnal Hortikultura, 24(3). pp. 222–230.

Dondu, Y., Sondakh, D.T. & Nangoi, R. (2023). Efektivitas penggunaan ekoenzim berbahan dasar beberapa macam buah terhadap pertumbuhan tanaman selada (*Lactuca sativa* L.). *Jurnal Agroteknologi Terapan,* 1(4), pp. 148–155.

Firnawati, O.C., Joni, M. & Defiani, M.R. (2025). Peningkatan pertumbuhan vegetatif tanaman cabai merah (*Capsicum annuum* L.) setelah aplikasi ekoenzim dan penyiraman secara berkala. *Simbiosis,* pp. 64–76.

Irfandri, I., Silvina, F., & Ramadhoni, R. (2025). Insidensi penyakit layu fusarium (*Fusarium oxysporum. F.* sp. *cepae*) pada daerah pengembangan bawang merah di Provinsi Riau. Agrikultura, 36(2), pp. 243 – 251.

Istikomah, N., Alami, N.H., & Purwani, K.I. (2015). Pengaruh ekstrak kulit jeruk pamelo terhadap pertumbuhan tanaman tomat yang terinfeksi jamur penyakit layu *Fusarium oxysporum*. Jurnal Sains dan Seni ITS 4(2)

Izzulsyah, I., Zeleansi, Z., Saputri, H., Kholisoh, & Amelia, R. (2023). Pendekatan metode autoregressive integrated moving average terhadap perkiraan harga bawang merah di Kota Pangkalpinang. In Proceedings of National Colloquium Research and Community Service 7, 22-26.

Kriswantoro, H., Nasser, G.A., Zairani, F.Y., Nisfuriah, L., Rompas, J.P., Dali, D., & Sofian, A. (2022). Utilization of Eco-enzyme from household organic waste to maintain soil fertility and plant pest control. Altifani Journal: International Journal of Community Engagement*,* 3(1), 7-11.

Maryam, A., Susila, A.D. & Kartika, J.G. (2015). Pengaruh jenis pupuk organik terhadap pertumbuhan dan hasil panen tanaman sayuran di dalam nethouse. Buletin Agrohorti, 3(2), 263–275.

Megah, S.I., Dewi, D., S., & Wilany, E. (2018). Pemanfaatan limbah rumah tangga digunakan untuk obat dan kebersihan. Minda Baharu, 2 (1), 50.

Miftahur, R., & Wahyuni, W., S. (2022). Pengendalian penyakit layu *Fusarium oxysporum f.sp. cepae* pada tanaman bawang merah dengan air rebusan serai dapur (*Cymbopogon citratus*). Berkala Ilmiah Pertanian,5(2), 65 – 69.

Monika, R., Mulyani, C., & Iswahyudi, I. (2025). Pengaruh waktu aplikasi dan konsentrasi PGPR akar bambu dalam menekan penyakit moler terhadap pertumbuhan dan produksi bawang merah (*Allium ascalonicum* L.). Jurnal Agrium 22(1), 63 – 76.

Nirmaladevi, D., Venkataramana, M., Srivastava, R. K., Uppalapati, S. R., Yeri, S. B., & Bhat, B. (2016). Molecular characterization and pathogenicity of Fusarium species associated with onion basal rot in India. Frontiers in Microbiology*, 7,* 31.

Nuryani, W., Widodo, & Santosa, E. (2019). Uji ketahanan beberapa varietas cabai terhadap penyakit antraknosa (*Colletotrichum* spp.). Jurnal Fitopatologi Indonesia*,* 15(5), 171–178.

Rahman, M. S., Hasan, M. M., & Saha, S. R. (2020). Growth and yield performance of onion (*Allium cepa* L.) under different irrigation regimes. Journal of Agriculture and Ecology Research International, 21(3), 1–10.

Sarma, M., Zorrilla-Fontanesi, Y., Uma, S., Vanderschuren, H., Swennen, R. & De Coninck, B. (2025). Suppression of *fusarium* wilt in banana and growth promotion by the beneficial fungus *Trichoderma asperellum* TRC900 is cultivar-dependent. Biological Control, 210, 105878.

Suganda, T., and Widiastuti, A. (2025). Optimalisasi Pengelolaan Fungisida dalam Penanganan Resistensi Jamur Patogen Tanaman. Penerbit Andi.

Sutanto, A., & Semiarti, E., 2019. Uji ketahanan beberapa varietas bawang merah terhadap penyakit layu fusarium. Jurnal Perlindungan Tanaman Indonesia, 23(1). pp.12–20.