



RESEARCH ARTICLE

Open Access

Effectiveness Test of Several Bioinsecticides and Chemical Insecticides on the Mortality of Whitefly Pests (*Bemisia tabaci*)



Iqbal Prayuda¹, Rini Susanti^{1*}, Zulaikha Binti Mazlan²

Abstract

Whitefly (*Bemisia tabaci*) is a major pest affecting various horticultural commodities and is challenging to control due to its high adaptability, rapid reproduction, and resistance to multiple chemical insecticides. This study aimed to compare the effectiveness of bioinsecticides and chemical insecticides on *B. tabaci* mortality. The research was conducted in the laboratory and greenhouse of the Malaysian Agricultural Research and Development Institute (MARDI) in September 2025, using a non-factorial Completely Randomized Design (CRD) with seven treatments and three replications. The seven treatments included Wood Vinegar, Paraffin Oil, Canola Oil, Neem Oil, Metarhizium anisopliae, Abamectin 1.8 EC, Diafenthiuron 250 SC, and water as the control. Applications were performed in the laboratory using the dipping method and in the greenhouse using the spraying method, with 30 *B. tabaci* nymphs per treatment and replication. Mortality was recorded at 24, 48, and 72 hours post-application. Laboratory results showed mortality rates of 24.44% for Wood Vinegar, 62.22% for Paraffin Oil, 71.11% for Canola Oil, 74.44% for Neem Oil, 70.00% for *M. anisopliae*, 38.89% for Abamectin, and 84.44% for Diafenthiuron. In the greenhouse, mortality rates were 16.67% for Wood Vinegar, 60.00% for Paraffin Oil, 67.78% for Canola Oil, 70.00% for Neem Oil, 62.22% for *M. anisopliae*, 30.00% for Abamectin, and 81.11% for Diafenthiuron 250 SC. Overall, among the chemical insecticides, Diafenthiuron exhibited the highest mortality and was the most effective treatment. Among the bioinsecticides, Neem Oil achieved the highest mortality. Based on these results, Neem Oil shows potential as a more environmentally friendly alternative control agent, while Diafenthiuron is suitable for use under conditions of high pest infestation.

Keywords: *Bemisia tabaci*, Bioinsecticide, Chemical Insecticide, Mortality, Whitefly

1. Introduction

Whiteflies (*Bemisia tabaci*) (Hemiptera: Aleyrodidae) are insects that have a significant economic impact on global agricultural production, particularly on vegetable and horticultural crops. *B. tabaci* has been reported to attack more than 600 plant species across 90 families, including important crops such as tomatoes, chilies, eggplants, beans, cucumbers, and cotton (Sani et al., 2020). Whiteflies are polyphagous pests that can infest various plant types and cause serious damage to agricultural productivity. This pest is commonly found on plants from the Solanaceae, Cucurbitaceae, and Fabaceae families. Plants infested by whiteflies typically exhibit symptoms

such as yellowing leaves, leaf curling or folding, and stunted growth (Habriantono et al., 2024). *B. tabaci* also acquires bacteria from the Enterobacteriaceae family that produce honeydew, which facilitates the development of a harmful sooty mold. This sooty mold reduces photosynthesis and diminishes crop yield quality (Ali & Yükselbaba, 2025).

The high adaptability of *B. tabaci* to environmental conditions, its rapid reproductive rate, and the diversity of host factors make this pest difficult to control. Mild and warm climatic conditions strongly influence large pest populations. In Southeast Asian countries, particularly Indonesia and Malaysia, the average temperature and

*Correspondence: rinisusanti@umsu.ac.id

1) Universitas Muhammadiyah Sumatera Utara - Jl. Kapten Muchtar Basri No.3, Glugur Darat II, Kec. Medan Timur, Kota Medan, Sumatera Utara 20238, Indonesia

2) Malaysian Agricultural Research and Development Institute (MARDI) - Ibu Pejabat MARDI, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia

humidity are believed to support the development of populations that enhance the proliferation of *B. tabaci* individuals. Furthermore, the biological complexity of this pest group indicates that it comprises thousands of species and taxa with high genetic diversity, though these differences are often not visible to the naked eye. Biological studies indicate that these variations affect the pest's survival, infestation levels, and its capacity to transmit diseases to host plants. (Li et al., 2023).

Generally, farmers control *B. tabaci* using synthetic insecticides from the *neonicotinoid*, *pyrethroid*, and *organophosphate groups* because of their rapid, practical, and easy-to-apply properties (Ali & Yükselbaba, 2025). However, the intensive and continuous use of synthetic insecticides has caused various problems, including pest resistance to insecticides, environmental pollution, disruption of natural enemies, and negative impacts on human health due to resulting residues (Barman et al., 2022). Resistance of *B. tabaci* to various insecticide classes has been reported in many countries, including *neonicotinoids* (*imidacloprid*, *thiamethoxam*, *acetamiprid*), *pyrethroids*, and even new insecticides such as *cyantraniliprole*. (Wang et al., 2023) .

The development of safer, more environmentally friendly, and sustainable alternative control strategies is essential to suppress *B. tabaci* populations and reduce dependence on synthetic insecticides. Botanical insecticides, also known as bioinsecticides, are naturally occurring, readily biodegradable insecticides that leave no harmful residues, are relatively safe for non-target organisms, and have a low potential to trigger pest resistance (Dimase et al., 2024).

In addition to botanical insecticides, the use of biological agents, such as entomopathogenic fungi, has been widely studied as an effective bioinsecticide for controlling *B. tabaci*. This fungus is often used in the manufacture of bioinsecticides. Fungal infection begins when virulent conidia come into contact with the sensitive surface of the insect cuticle. Insect stages such as moulting larvae and young pupae are more susceptible to fungal attack than individuals whose cuticles have hardened, because their protective layer is still thin and easily penetrated by fungal hyphae (Ryzaldi et al., 2022).

Repeated and uninterrupted use of insecticides, especially at higher doses, can trigger the development of direct resistance in pests (Fitria et al., 2021). Modern chemical insecticides with new active ingredients such as *cyantraniliprole*, *flonicamid*, *spiromesifen*, and *flupyradifurone* have been developed with different modes of action and reported to be effective in controlling *B. tabaci* that has become resistant to conventional insecticides (Mohapatra et al., 2024). Botanical insecticides, such as neem oil and paraffin oil, have also been reported to be effective in controlling *B. tabaci* (Habriantono et al., 2024). However, comparing the

efficacy of bioinsecticides and chemical insecticides, particularly regarding *B. tabaci* mortality, requires further investigation to identify the most effective and sustainable control strategy within the framework of Integrated Pest Management (IPM). Therefore, this study aims to evaluate and compare the effectiveness of bioinsecticides derived from plant extracts and entomopathogenic fungi with that of chemical insecticides on whitefly (*B. tabaci*) mortality. The findings of this study are expected to provide comprehensive scientific insights into the potential of bioinsecticides as environmentally friendly alternatives for controlling *B. tabaci*, thereby supporting the implementation of IPM strategies in sustainable agricultural production systems.

2. Material and Methods

2.1. Place and Time

This research was conducted at the Greenhouse and Quarantine Treatment Laboratory of the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor, Malaysia, with coordinates 2°59'18.1" North 101°42'5.8" East, with an altitude of ± 36 meters above sea level (masl). This research was conducted in September 2025.

2.2. Materials and tools

The materials used in this study included whitefly nymphs (*B. tabaci*), tomato plant leaves of the King Granite TM3069 variety, and water (Aquadest). The active ingredients tested from different trademarks consisted of chemical insecticides, namely *Diafenthiuron* 250 SC (*Pegasus* 250 SC) and *Abamectin* 1.8 EC (*Agrimectin* 1.8 EC), as well as bioinsecticides, including *Neem Oil Extract*, *Wood Vinegar* (HR3), *Metarhizium anisopliae fungus* (WAN), *Canola Oil* (*Jadam Wetting Agent*), and *Paraffin Oil* (*Albarol*). The tools used included a 500 mL beaker, a petri dish, a 500 mL hand sprayer, 1 and 5 cc syringes, personal protective equipment, label paper, a stereo microscope (Leica), scissors, stationery, and other supporting equipment.

2.3. Research methods

This research used two methods: the laboratory-dipping method and the greenhouse-spray method, both with the same treatment. This study used a non-factorial Completely Randomized Design (CRD) with 7 treatments and water as the control, each repeated 3 times. Each replication consisted of 30 *B. tabaci* nymph samples. The concentration of each insecticide treatment was determined according to the label of each insecticide package, and each concentration was dissolved in 300 mL of distilled water. The treatments used were:

- 1) Water (Control) = 300 mL Water
- 2) Wood Vinegar = 1.5 mL
- 3) Paraffin Oil = 0.51 mL
- 4) Canola Oil = 4.8 mL

- 5) Neem Oil = 0.45 mL
- 6) *M. Anisopliae* = 0.375 g
- 7) Abamectin 1.8 EC = 0.27 mL
- 8) *Diafenthiuron* 250 SC = 0.72 mL

2.4. Research Implementation

2.4.1. Implementation of the Dipping Method in the Laboratory

The laboratory research on the dipping method began with preparing insecticide treatments dissolved to their respective concentrations in a 500 mL beaker. Then, *B. tabaci* nymph samples were collected from leaves of the King Granite TM3069 tomato variety grown in a greenhouse, with 1 leaf per replication. After collection and transport to the laboratory, the leaves containing the samples were immediately dipped in each treatment for 10 seconds. After the dipping process, the leaves containing the samples were placed in a petri dish labeled for each treatment and replication. Afterward, 30 nymph samples were counted for each treatment in each replication, and each sample tested was marked to avoid errors in calculating mortality. Mortality was observed at 24, 48, and 72 hours after application. Observations were made using a stereo microscope (Leica).

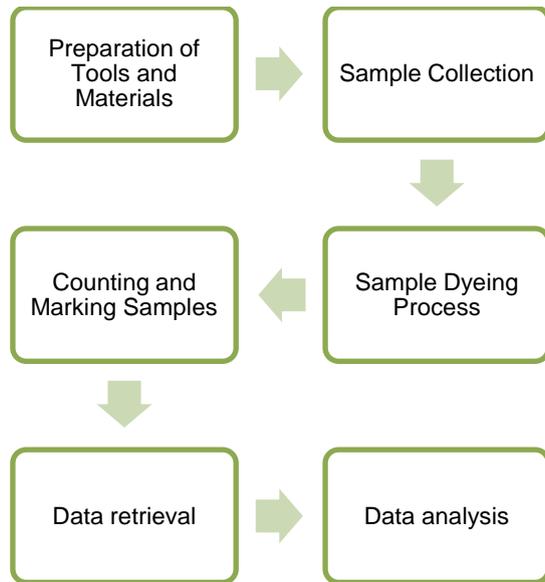


Figure 1. Flowchart of Dipping Method Research in the Laboratory

2.4.2. Implementation of the Spray Method in Greenhouses

The research using the spray method conducted in the greenhouse began with preparing insecticide treatments dissolved to their respective concentrations, then pouring them into 500 mL spray bottles. The test samples used were *B. Tabaci* nymphs are found on the leaves of King Granite TM3069 tomato plants cultivated in the greenhouse. Next, the process of attaching treatment and replication labels

was carried out on each leaf of the tomato plant containing *B. Tabaci* nymphs, with 1 leaf being 1 replication. After that, spraying was carried out according to the treatment used, with a spray distance of 20-30 cm. After 24 hours, 30 nymph samples attached to the leaves were counted for each treatment and replication, and each sample was marked to avoid errors when calculating mortality. Afterward, mortality was observed at 24, 48, and 72 hours after application.

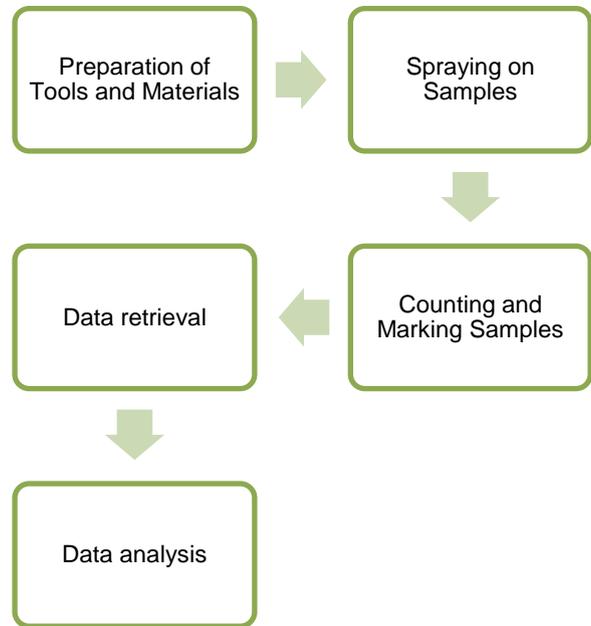


Figure 2. Flowchart of Spray Method Implementation in Greenhouses

2.5. Mortality Percentage

The observed parameter was the mortality rate of *B. tabaci* following application of various insecticides. The mortality percentage of *B. tabaci* was calculated using the formula used by Syahbani & Saragih (2025), as follows:

$$p = a/b \times 100\%$$

Information:

- p = Percentage of pest mortality
- a = Total number of pests killed
- b = Total pests observed

2.6. Data analysis

Data on the percentage of *B. tabaci* nymph mortality from each bioinsecticide and chemical insecticide treatment were analyzed using a non-factorial Completely Randomized Design (CRD) with further Duncan’s Multiple Range Test (DMRT) at the α level of 5% using SPSS 29 software.

3. Results and Discussion

3.1. Dipping Method Research in the Laboratory

Table 1. Average Mortality of *B. tabaci* with the Dipping Method

Treatment	Average Mortality %
Water (Control)	0.00 ± 0.00 a
Wood Vinegar	24.44 ± 2.94 b
Paraffin oil	62.22 ± 2.94 c
Canola Oil	71.11 ± 4.84 cd
Neem Oil	74.44 ± 5.88 cd
<i>M. anisopliae</i>	70.00 ± 6.94 cd
Abamectin 1.8 EC	38.89 ± 2.94 b
Diafenthiuron 250 SC	84.44 ± 8.01 d

Note: Numbers followed by different letters in the same column are significantly different according to the 5% Duncan test

Based on the data in Table 1, all treatments differed significantly from the control (water), indicating that the control did not cause mortality in *B. tabaci* because it contained no active ingredients. Therefore, it can be concluded that the mortality observed in the other treatments was entirely due to the effects of the applied active ingredients. Among the chemical insecticides, the active ingredient Diafenthiuron 250 SC produced the highest mortality rate and was the most effective in controlling *B. tabaci*, with a mortality value of 84.44%. This result was significantly greater and more effective than that of Abamectin 1.8 EC. The high mortality rate is attributed to Diafenthiuron's classification as a thiourea compound, which acts as both a contact and stomach poison, making it effective in suppressing the *B. tabaci* population. These findings are consistent with the research of Haider et al. (2023), which reported that Diafenthiuron is an effective insecticide that yields significant results against whiteflies. Meanwhile, the active ingredient Abamectin 1.8 EC provided a low mortality value of only (38.89%) which was not significantly different from the Wood Vinegar treatment. This low mortality rate is likely due to pest resistance to the active ingredient Abamectin. According to, continued use of synthetic insecticides at the same dosage and active ingredient will result in a subsequent population dominated by resistant insects.

In terms of bio-insecticides, Neem Oil has the highest mortality rate, with a mortality value of 74.44%. While other treatments with lower mortality values are Canola Oil (71.11%), *M. anisopliae* entomopathogenic fungus (70.00%), and Paraffin Oil (62.22%). These four treatments were proven to be effective in controlling *B. tabaci* and were not significantly different from each other according to Duncan's further test at the 5% level. Meanwhile, the bio-insecticide treatment with the lowest mortality rate and proven to be ineffective enough to control *B. tabaci* was the Wood Vinegar treatment with a mortality value of only 24.44%, which was significantly different from all treatments.

Neem oil can produce the highest mortality compared to all other bioinsecticide treatments because the Neem plant contains several compounds, namely azadirachtin, salanin, and nimbin, which function to cause death in *B.*

tabaci. In line with the research of Indiati & Marwoto (2008), which stated that the azadirachtin compound contained in the Neem plant acts as an inhibitor of insect metamorphosis hormones, so that insects fail to metamorphose and eventually die. Research by Maudodi et al. (2024) also found that the compounds in Neem extract do not directly kill insects but reduce their appetite, growth, and reproductive ability. Furthermore, Canola Oil also has a mortality rate no lower than Neem Oil, namely 71.11%. This finding also shows that Canola Oil is quite effective in controlling *B. tabaci*. However, when using doses that are too high or not in accordance with the recommended use, it can cause phytotoxicity in plants, as indicated by blackened leaves. According to Febritami et al. (2019), symptoms of necrosis or shriveled leaves are caused by the death of plant cells exposed to insecticide liquid at high doses and toxicity.

Treatment with the entomopathogenic fungus *M. anisopliae* also resulted in a relatively high mortality rate of 70.00%. This finding indicates that the entomopathogenic fungus *M. anisopliae* is highly effective at controlling *B. tabaci*. Mortality occurs due to contact between the fungal conidia and the insect cuticle. These conidia develop and penetrate the insect's Body, damaging its internal tissues and leading to insect death (Nasution et al., 2021).

The lowest bio-insecticide treatment was Wood Vinegar treatment, which produced a mortality rate of only 24.44%. This low mortality rate occurred because the concentration used was not strong enough to produce a high mortality rate. According to Syahbani & Saragih (2025), the higher the insecticide concentration, the higher the compound content and the shorter the time required to kill insects.

3.2. Spray Method Research in Greenhouses

Based on the data in Table 2, it was found that all treatments were significantly different from the control (water), which showed that the control treatment (water) did not result in *B. tabaci* mortality because no active ingredients were applied. It can be concluded that mortality in the other treatments was entirely due to the effects of the active ingredients administered. Among the chemical insecticides, the active ingredient Diafenthiuron 250 SC had the highest mortality rate and was the most effective in

controlling *B. tabaci*, with a mortality value of 81.11%, which was significantly higher than all treatments except the Neem Oil treatment. Meanwhile, the Abamectin 1.8 EC

treatment resulted in low mortality of only 30.00%, which was significantly lower than that of all treatments.

Table 2. Average Mortality of *B. tabaci* with Spray Method

Treatment	Average Mortality %
Water (Control)	0.00 ± 0.00 a
Wood Vinegar	16.67 ± 3.85 b
Paraffin oil	60.00 ± 3.33 d
Canola Oil	67.78 ± 4.01 d
Neem Oil	70.00 ± 3.85 de
<i>M. anisopliae</i>	62.22 ± 2.94 d
Abamectin 1.8 EC	30.00 ± 3.85 c
Diaphenthiuron 250 SC	81.11 ± 7.78 e

Note: Numbers followed by different letters in the same column are significantly different according to the 5% Duncan test.

From the bioinsecticide side, Neem Oil treatment has the highest mortality rate, reaching 70.00%, which is significantly different from all treatments except the Abamectin 1.8 EC treatment, indicating that this treatment is quite effective in controlling *B. tabaci*. However, the Wood Vinegar treatment has the lowest mortality rate of all treatments, with a mortality value of 16.67%, which is significantly lower than all other treatments, indicating that this treatment is not effective enough to control *B. tabaci*. While other treatments, such as Canola Oil (67.7%), *M. anisopliae* (62.22%), and Paraffin Oil (60.00%), show moderate mortality rates and are not significantly different from each other.

Overall, laboratory and chemical insecticide efficacy tests showed higher mortality rates than those in greenhouse tests. This is likely due to the highly controlled laboratory conditions, allowing the insecticides to work optimally without external interference. Furthermore, *B.*

tabaci samples were placed in petri dishes, limiting their movement and increasing the likelihood of contact between the insecticide active ingredient and the insect samples, ultimately accelerating mortality. Conversely, greenhouse tests showed lower mortality rates due to fluctuating environmental factors and the presence of living plant media, which allowed *B. tabaci* to avoid direct contact with the insecticide active ingredient. Research by Cremonez et al. (2023) found that laboratory bioassay methods yielded higher efficacy against *B. tabaci* than field methods.

3.3. Symptoms of Death of *B. tabaci*

3.3.1. Symptoms of Death Effects of Insecticides

B. tabaci death symptoms caused by insecticides were carried out using a stereo microscope (Leica), and observations were made at time intervals of 24, 48, and 72 hours after application.

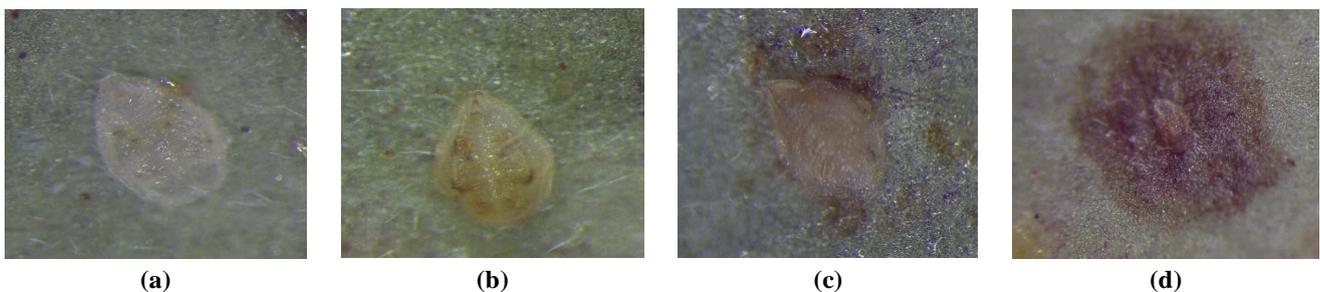


Figure 1. Symptoms of Death Due to Insecticides: (a) *B. tabaci* in Healthy Condition, (b) *B. tabaci*'s Color Becomes Brownish (24 JSA), (c) *B. tabaci*'s Color Becomes Blackish Brown (48 JSA), (d) *B. tabaci*'s Body Shrinks and Dries Up (72 JSA)

Symptoms that appear in *B. tabaci* nymphs 24 hours after application are that the Body of the *B. tabaci* nymph begins to appear pale and changes color to brown. After 48 hours, the Body of the *B. tabaci* nymph begins to show a change in color to blackish brown. After 72 hours, the Body of the *B. tabaci* nymph begins to shrink and dry out because the fluid in the insect's Body begins to come out. All insecticide treatments, both bioinsecticides and chemical insecticides, act as contact poisons. The active

ingredient of the insecticide penetrates the insect's cuticle, allowing it to enter the internal body tissues. The active compound is distributed throughout the insect's Body through the circulatory system, so it can reach vital organs such as the nervous system, muscles, and respiratory tract, which can disrupt balance and cause death in *B. tabaci*. Research conducted by Syahbani & Saragih (2025) states that contact poisons function by penetrating the target insect's Body through the skin layer or cuticle, then

entering the body tissue to disrupt physiological systems and cause death.

3.3.2. Symptoms of Death Due to *M. anisopliae*



Figure 2. (Symptoms of Death Due to *M. anisopliae* : (a) *B. tabaci* in Healthy Condition, (b) *B. tabaci*'s Body Becomes Pale (24 JSA), (c) *B. tabaci*'s Body Begins to Grow Mycelium (48 JSA), (d) Mycelium Begins to Fill *B. tabaci*'s Body (72 JSA)

Symptoms that appear in *B. tabaci* nymphs 24 hours after application are that the Body of the *B. tabaci* nymph begins to appear pale, but no fungal hyphae are yet visible. After 48 hours, the body color of *B. tabaci* begins to turn brown, and fungal mycelium is already visible. After 72 hours, the mycelium of *M. anisopliae* begins to fill the Body of *B. tabaci*. This result can occur because the fungus that begins to infect *B. tabaci* interferes with its metabolism and respiration, causing organ damage and leading to death. After *B. tabaci* dies, fungal hyphae begin to grow and form a greenish mycelium that eventually covers all parts of the insect's Body. Research by Ryzaldi et al. (2022) found that insects infected with *M. anisopliae* showed decreased feeding activity, then their bodies became stiff and hardened after death, accompanied by hyphal growth that began to appear on the second day after infection.

4. Conclusion

Overall, among the chemical insecticides, diafenthiuron treatment resulted in the highest mortality and was the most effective. Among the bioinsecticides,

The effects of *B. tabaci* death caused by the fungus *M. anisopliae* were observed using a stereo microscope (Leica) at 24, 48, and 72 hours after application.

neem oil treatment achieved the highest mortality. Based on these results, neem oil has the potential to serve as a more environmentally friendly control alternative, while diafenthiuron can be applied under severe pest infestation conditions.

Acknowledgments

The authors would like to express their deepest gratitude to the Muhammadiyah University of North Sumatra (UMSU) for providing the facilities necessary to conduct the International Field Work Practice (PKL) program. They also extend their thanks to the Malaysian Agricultural Research and Development Institute (MARDI) for the opportunity to study and conduct research. The authors are grateful to Puan Zulaikha Binti Mazlan and Mr. Wan Muhammad Azrul Bin Wan Azhar, Research Staff at MARDI, for their assistance and involvement throughout the research process. Additionally, thanks are extended to Mrs. Rini Susanti, the supervising lecturer, for her support in completing the writing of this article.

References

- Ali, I. H., & Yükselbaba, U. (2025). Determination of resistance improving potentials of cotton whitefly *Bemisia tabaci* (Genn.) (Hemiptera: Aleyrodidae) biotypes against cyantraniliprole. *Plant Protection Science*, 61(2), 191-200. <https://doi.org/10.17221/112/2023-PPS>
- As'ad, M. F., Kaidi, F., & Syarief, M. (2018). Status resistensi walang sangit (*Leptocorisa acuta* F.) terhadap insektisida sintetik dan kepekaannya terhadap *Beauveria bassiana* pada tanaman padi. *Agriprima: Journal of Applied Agricultural Sciences*, 2(1), 79-86. <https://doi.org/10.25047/agriprima.v2i1.80>
- Barman, M., Samanta, S., Upadhyaya, G., Thakur, H., Chakraborty, S., Samanta, A., & Tarafdar, J. (2022). Unraveling the basis of neonicotinoid resistance in whitefly species complex: Role of endosymbiotic bacteria and insecticide resistance genes. *Frontiers in Microbiology*, 13, 1-15. <https://doi.org/10.3389/fmicb.2022.901793>
- Cremonese, P. S. G., Perier, J. D., Nagaoka, M. M., Simmons, A. M., & Riley, D. G. (2023). Precision and accuracy of field versus laboratory bioassay insecticide efficacy for the control of immature *Bemisia tabaci*. *Insects*, 14(7). <https://doi.org/10.3390/insects14070645>
- Dimase, M., Lahiri, S., Beuzelin, J., Hutton, S., & Smith, H. A. (2024). Evaluation of biopesticides for management of *Bemisia tabaci* Middle East-Asia Minor 1 (Hemiptera: Aleyrodidae) in Florida. *Insects*, 15(6), 1-16. <https://doi.org/10.3390/insects15060438>
- Febritami, G., Usyati, N., & Dono, D. (2019). Toxicity of four kinds of plant extracts (*Ageratum conyzoides* L., *Barringtonia asiatica* (L.) Kurz., *Melia azedarach* L., *Tephrosia vogelii* Hook. f.) against brown planthopper (*Nilaparvata lugens* Stål). *CROPSAVER - Journal of Plant Protection*, 1(1), 1. <https://doi.org/10.24198/cropsaver.v1i1.16970>
- Fitria, F., Susanti, R., & Lubis, E. (2021). Pengaruh dosis tiga macam insektisida terhadap serangan hama lalat bibit pada tanaman kedelai (*Glycine max* L.). *Jurnal SOMASI (Sosial Humaniora Komunikasi)*, 2(2), 163-167. <https://doi.org/10.53695/js.v2i2.608>
- Habriantono, B., Masnilah, R., & Alfarisy, F. K. (2024). Pengelolaan serangan kutu kebul (*Bemisia tabaci* Genn.) pada tanaman cabai (*Capsicum annum* L.) di rumah kaca. 24(2), 131-139.
- Haider, I., Riaz, M., Ali, S., Ali, Q., Noman, A., Hussain, D., Nadeem, I., Akhtar, M. F., Abbas, A., Aslam, A., Mustafa, H. S. B., Hassan, E. U., Zubair, M., Saleem, M., & Malik, M. K. (2023). Efficacy of different insecticides alone and in combination with salicylic acid against cotton whitefly *Bemisia tabaci* Gennadius

- (Homoptera: Aleyrodidae). *Pakistan Journal of Agricultural Research*, 36(1), 58-62. <https://doi.org/10.17582/journal.pjar/2023/36.1.58.62>
- Indiati, S. W., & Marwoto, M. (2008). Potensi ekstrak biji mimba sebagai insektisida nabati. *Buletin Palawija*, 15, 9-14. <https://doi.org/10.21082/bulpalawija.v0n15.2008.p9-14>
- Li, H., Jiang, Z., Zhou, J., Liu, X., Zhang, Y., & Chu, D. (2023). Ecological factors associated with the distribution of *Bemisia tabaci* cryptic species and their facultative endosymbionts. *Insects*, 14(3). <https://doi.org/10.3390/insects14030252>
- Maudodi, R. S., Rizali, A., & Marsuni, Y. (2024). Uji efektivitas pestisida nabati dari daun mimba terhadap kematian ulat grayak (*Spodoptera litura* F.). *Agroekotek View*, 7(3), 45-53.
- Mohapatra, S., Padhi, J., & Singh, S. (2024). Enhancing yield and economic benefits through sustainable pest management in okra cultivation. *Scientific Reports*, 14(1), 1-14. <https://doi.org/10.1038/s41598-024-72997-6>
- Nasution, L., Cemda, A. R., Isnaini, S., Afrillah, M., & Filsa, P. (2021). Pemanfaatan jamur *Metarhizium anisopliae* berasal dari isolat *Brontispa longissima* mengendalikan larva *Oryctes rhinoceros* secara *in vitro*. *Agrica Ekstensia*, 15(2). <https://doi.org/10.55127/ae.v15i2.101>
- Ryzaldi, M. L., Oktarina, O., Murtiyaningsih, H., Hasbi, H., & Aldini, G. M. (2022). Pemanfaatan jamur entomopatogen *Metarhizium anisopliae* (Metsch.) sebagai bioinsektisida dalam mengendalikan hama kepik penghisap buah (*Helopeltis* spp.) pada kakao (*Theobroma cacao* L.). *Jurnal Penelitian Ilmu Sosial dan Eksakta*, 2(1), 51-60. <https://doi.org/10.47134/trilogi.v2i1.39>
- Sani, I., Ismail, S. I., Abdullah, S., & Jalinas, J. (2020). A review of the biology and control of whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae), with special reference to biological control using entomopathogenic fungi. *Insects*, 11, 18.
- Syahbani, R. N., & Saragih, S. A. (2025). Efektivitas insektisida nabati daun sirsak dan sirih hijau terhadap mortalitas rayap. 28(1), 24-33.
- Wang, Q., Luo, C., & Wang, R. (2023). Insecticide resistance and its management in two invasive cryptic species of *Bemisia tabaci* in China. *International Journal of Molecular Sciences*, 24(7). <https://doi.org/10.3390/ijms24076048>