AGRIUM
Jurnal Ilmu Pertanian
pISSN 0852-1077; eISSN 2442-7306

April 2026 Volume 29 No.1: 33- 44
https://jurnal.umsu.ac.id/index.php/agrium/article/view/25999

Induction of Tomato Plant Resistance to the Whitefly *Bemisia tabaci* Using the Entomopathogenic Fungus *Beauveria bassiana*

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Abstract

Whitefly (Bemisia tabaci) is a major pest on tomato plants. Whiteflies not only attack plants directly but also serve as vectors for viruses that spread diseases such as geminiviruses, causing plants to turn yellow. One alternative for controlling this pest is to use entomopathogenic fungi, such as Beauveria bassiana. This study aimed to isolate a B. bassiana strain that enhances tomato plant resistance to B. tabaci. The experiment was arranged in a Completely Randomized Design (CRD) with six treatments and five replications. The treatments included five isolates of B. bassiana, namely BbWs, TD312, PA221, PD114, and PB21 plus a control. The B. bassiana concentration used was 10^8 *conidia/mL. The fungus was applied by soaking tomato seed lots. Results showed that seed soaking with B. bassiana significantly reduced egg, nymph, and adult populations across all isolates compared to the control. Notably, PA221 and TD312 isolates showed significant nymph suppression. Five weeks after planting, the TD312 isolate resulted in the lowest populations: 20.40 eggs per plant, 7.25 nymphs per plant, and 2.30 adults per plant. Additionally, B. bassiana application affected plant morphology by increasing trichome density; plants treated with TD312 had a trichome density of 616.73 trichomes/cm², higher than the control (295.73 trichomes/cm²). Although statistically comparable to several other isolates on some parameters, TD312 consistently exhibited the lowest pest counts and the highest trichome density, indicating its potential to enhance tomato resistance to B. tabaci by suppressing pest populations and reinforcing trichome density.*

Keywords: *Egg, endophytes, fungi, Gemini virus, nymph.*

Received: 22 July 2025; **Revised:** 19 September 2025; **Accepted:** 9 April 2026

INTRODUCTION

The whitefly (*Bemisia tabaci* Gennadius, 1889 is a significant pest of tomato plants. *B. tabaci* damages plants by piercing tissue and sucking phloem fluid from tomato leaves, causing abnormal plant growth, wilting, and decreased productivity (Agastya et al., 2020). Whiteflies not only attack plants directly but also act as vectors for viruses that transmit diseases such as Geminivirus, which causes yellowing (Soumia et al., 2021). Their role as pests and disease vectors in plants can cause significant yield losses, reaching 90-100% (Hidayat et al., 2020).

Standard methods of controlling whitefly pests used by farmers include adjusting planting times, planting resistant varieties, using barrier plants, crop rotation, and applying synthetic insecticides (Inayati and Marwoto, 2015). The most common method of controlling whiteflies is using insecticides. However, these insecticides are considered ineffective because the insect's body is coated with wax, making it difficult for the active ingredient to penetrate. Whiteflies typically live under the surface of leaves, and their adults fly, making it difficult for insecticide sprays to reach their target. Furthermore, the pest is suspected to belong to a lineage resistant to many insecticides (Sugiyama, 2005; Mota-Sanchez and

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Wise, 2019; Horowitz et al., 2020). Besides that, the intensive use of synthetic insecticides can lead to resistance, pest resurgence, the elimination of natural enemies, the accumulation of harmful residues on agricultural products, environmental pollution, and a risk to human health. One of the more environmentally friendly pest control efforts that also suppresses the development of pest resistance or resurgence is the use of biological agents such as the fungus *Beauveria bassiana* (Erdiansyah et al., 2023; Hendra et al., 2026).

B. bassiana is an entomopathogenic fungus widely used as an effective biological control agent against various insect pest species, including the cabbage pest *Crocidolomia pavonana* (Trizelia and Nurdin, 2010), *Spodoptera exigua* (Razak et al., 2016), *S. litura* (Trizelia et al., 2016), *Nezara viridula* (Siahaan et al., 2021), *Bemisia tabaci* (Flawerina, 2021), *Eurydema pulchrum* (Trizelia et al., 2019), *Nilaparvata lugens* (Hendra et al., 2022), and Thrips sp. on chili plants (Sofwah and Prastowo, 2023)

As knowledge advances, B. bassiana is not only an entomopathogen capable of directly infecting and killing insects. Still, it is also reported to live as an endophyte in various plant species and to colonize plant tissues. The colonization of endophytic fungi in plant hosts can negatively affect insects, especially those that feed on the host and become pests, thereby enhancing plant resistance to pest attacks. The plant's ability to inhibit pest development is a complex process regulated by various compounds, including salicylic acid, jasmonic acid, and ethylene (Kessler & Baldwin, 2002). The presence of *B. bassiana* in plant tissues can occur naturally (as a natural endophyte) or be artificially introduced through seed inoculation, foliar application, seedling and vegetative propagation material soaking, soil drenching, and injection (Vega, 2018; Bamisile et al., 2018; Saragih, 2019).

The ability of *B. bassiana* to live endophytically in plants and enhance plant resistance to pest attacks has been reported by several researchers. Gautam et al. (2016) found that B. *bassiana* can live endophytically in cauliflower plants, reducing the number of *Plutella xylostella* eggs and causing up to 100% larval mortality. This mortality results from *B. bassiana*'s ability to reside in plant tissues and produce secondary metabolites toxic to larvae. Batool et al. (2020) reported that *B. bassiana* can live endophytically in corn plants. Its presence reduces *Ostrinia furnacalis* (Guenee) larvae by up to 85%, decreasing the number and length of larval tunnels. Larval mortality is attributed to secondary metabolites such as proline and polyphenol oxidase found in corn plants, which are toxic to larvae. Trizelia et al. (2020) reported that chili plants inoculated with *B. bassiana* can suppress the development of *Myzus persicae* populations. Hendra et al. (2023) found that applying *B. bassiana* to rice plants through seed soaking affects the oviposition preferences of adult brown planthoppers (*Nilaparvata lugens*). The number of eggs laid by adult planthoppers was lower in *B. bassiana*-treated rice plants. The presence of *B. bassiana* in rice tissues reduces the percentage of planthopper eggs that hatch by 62.8% and increases nymph mortality by 46%. It also affects adult planthopper mortality. The presence of *B. bassiana* in rice stems can increase secondary metabolite levels, such as salicylic acid and oxalic acid, and decrease primary metabolite levels, such as sucrose (Hendra, 2022).

The ability of B. bassiana to colonize plant tissues is affected by application methods, plant age (Posada and Vega, 2005), and the specific fungal strain used (Zhang, 2014). The presence of endophytic fungi within plant tissues can promote the production of various toxic or antifeedant compounds (Gao et al., 2010; McCormick et al., 2016). The relationship between applying B. bassiana to tomato plants and the development of aphid populations warrants further study. This research aims to isolate a B. bassiana strain that effectively reduces *B. tabaci* populations.

MATERIALS AND METHODS

Place and Time

This study was conducted at the Biological Control Laboratory, Department of Plant Protection, Faculty of Agriculture, Universitas Andalas, and at the Experimental Farm of Universitas Andalas in Padang from July to October 2024.

Materials and Tools

The materials used in this research were an isolate of the fungus *Beauveria bassiana*, whiteflies, Sabouraud Dextrose Agar supplemented with Yeast Extract (SDAY), tomato seeds of the Selena variety, soil, 5-kg polybags, heat-resistant plastic, 70% alcohol, distilled water, Tween 80, tissue paper, plastic wrap, millimeter paper, labels, and stationery.

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The tools used in this study included Petri dishes (9 cm in diameter), test tubes, a test tube rack, Schott bottles, a Bunsen burner, an autoclave, a laminar air flow cabinet, an oven, an analytical balance, drop pipettes, a micropipette and tips, a haemocytometer, a spatula, object glasses, cover glasses, a vortex mixer, a cork borer, pot trays, scissors, a fine brush, tweezers, an Olympus CX23 microscope, and a smartphone camera**.**

Method

This study employed an experimental method using a Completely Randomized Design (CRD) with six treatments and five replications. The treatments comprised five isolates of *Beauveria bassiana* and a control treatment. The treatments were as follows:
A = Control (immersion using sterile distilled water)
B = Isolate PA221 (chili root endophyte, Parabek, Agam)
C = Isolate BbWs (*Leptocorisa oratorius*, Duku, Padang Pariaman)
D = Isolate PB211 (chili stem endophyte, Parabek, Agam)
E = Isolate PD114 (chili leaf endophyte, Parabek, Agam)
F = Isolate TD312 (wheat stem endophyte, Koto Laweh, Tanah Datar)

Propagation of *Beauveria bassiana*

The *B. bassiana* fungal isolate used was obtained from the Biological Control Laboratory at the Faculty of Agriculture, Andalas University. *B. bassiana* fungi were propagated using Sabouraud Dextrose Agar Yeast (SDAY) media. *B. bassiana* fungal propagation was carried out by transferring pure fungal cultures with a 0.7 cm diameter cork borer to a petri dish containing SDAY media and incubated at 28 °C for 21 days until fungal conidia were formed and ready for use.

Preparation of *Beauveria bassiana* Suspension

Conidia of a 21-day-old *B. bassiana* fungal isolate were collected by adding 10 ml of sterile distilled water and three drops of Tween 80 solution as a leveling agent to a petri dish. All ingredients were mixed using a soft brush to loosen the conidia, then transferred to a test tube and homogenized using a vortex. Next, serial dilutions were performed up to 3 times, and the final conidial concentration was 10^8 conidia/mL. The density of fungal conidials was calculated using a hemocytometer (Impoved Neubeur) (González-Guzmán et al., 2021; Ibrahima et al., 2022).

Preparation of Planting Media

The planting medium consisted of a 2:1 (v/v) mixture of sterile soil and manure. The soil and manure mixture was sterilized using the Tyndallization method, which involves heating the mixture to 100°C for 1 hour in a steamer, followed by a 24-hour incubation, then reheating the mixture three times at 100°C. The sterilized soil was placed in 5 kg polybags and was ready for use as a planting medium (Gullino et al., 2022)

Treatment of Tomato Seeds with *B. bassiana* Fungus

The tomato seeds used in this experiment were of the Selena variety. Before treatment, the seeds were surface-sterilized by sequential soaking: first in sterile distilled water for 1 minute, then in 70% ethanol for 1 minute, and finally rinsed again in sterile distilled water for 1 minute. After sterilization, the seeds were air-dried for 10 minutes inside a Laminar Air Flow Cabinet. Once dry, the seeds were immersed in a 10 mL suspension of B. bassiana at 10^8 conidia/mL for 6 hours, as described by Trizelia (2020). After soaking, the seeds were placed in petri dishes lined with sterile filter paper and allowed to dry for one hour. The fully dried seeds were then sown into the prepared planting medium.

Seed Sowing and Seedling Planting

Tomato seeds soaked in a suspension of the fungus B. bassiana are planted in plastic seed trays filled with a 2:1 soil and manure mixture, which has been kept moist. The planting medium is gently hollowed out with small pieces of wood, 0.5-1 cm deep, and two tomato seeds are placed in each hole. Then, the medium is evenly covered again. Watering is performed daily under moist soil conditions (Pandey et al., 2023).

The 21-day-old tomato seedlings were transferred into polybags filled with a mixture of manure and sterilized soil. One tomato seedling was planted in each polybag. The polybags were then arranged according to the tomato planting distance, 40 cm x 60 cm (Singh & Shrama, 2022; Melo et al., 2024).

Tomato Plant Maintenance

Tomato plants are watered once a day, either in the morning or the evening. They are staked at 3 months of age. The stakes are made from 1-meter-long bamboo strips placed vertically beside the tomato plants. Fertilization is done by applying NPK fertilizer around the plants at a distance of 10 cm and a depth of 5 cm. This fertilization is performed twice: once a week after planting and again four weeks later. Weeds are removed manually every two weeks.

Observation of the *B. tabaci* Population in Tomato Plants

Observations of the B. tabaci population were made by counting adults, nymphs, and eggs in each treatment. Pest population data were collected every 7 days, during morning hours. Observations started when plants were 2 weeks old and continued until 5 weeks after planting. Adults were counted directly on the plants. Nymph and egg populations were estimated by sampling three leaves from the top, middle, and bottom of each plant. The numbers of nymphs and eggs were then counted in the laboratory using a microscope (Kumar et al., 2023; Smith et al., 2024).

Counting the Number of Trichomes on Leaves

Trichome counts were performed by collecting three leaves (top, middle, and bottom) from each plant for each treatment. The leaves were cut into 1 cm² pieces, and trichomes were counted under a microscope (Xu et al., 2023; Earsakul et al, 2025).

Data Analysis

The data obtained were presented in tables, and the standard error (SE) was calculated. The data were analyzed using analysis of variance (ANOVA) in Statistix 8, and when significant differences were detected, a post hoc test was performed at the 5% significance level**.**

RESULTS AND DISCUSSION

Population of *B. tabaci* egg

Applying B. bassiana to tomato plants through seed soaking significantly reduced the number of B. tabaci eggs across all tested fungal isolates. Analysis of variance showed a notable difference between treatments with B. bassiana isolates and the control group. The average number of B. tabaci eggs per plant at five weeks after planting is detailed in Table 1.

Table 1. Average Number of *Bemisia Tabaci* Eggs on Tomato Plants Treated with *Beauveria Bassiana* Fungus at 5 Weeks After Planting

Treatment	Egg number/plant ± SE
Control	81.10 ± 3.32 a
PA221	37.40 ± 10.69 b
PB211	35.20 ± 4.23 bc
PD114	33.65 ± 3.38 bc
BBWs	25.70 ± 4.30 bc
TD312	20.40 ± 4.84 c

Note: Means within the same column followed by the same lowercase letter are not significantly different according to LSD at the 5% level.

As shown in Table 1, all treatments with B. bassiana isolates significantly reduced the number of eggs laid by B. tabaci compared to the control. The PA221 isolate had the highest average number of eggs (37.40 per plant). All B. bassiana treatments significantly lowered B. tabaci egg populations compared to the control (Table 1). Although TD312 had the lowest egg count (20.40 per plant), it was not statistically different from BBWs (25.70), PD114 (33.65), or PB211 (35.20). Only PA221 (37.40) had a significantly higher egg count than TD312. These results show that most isolates, especially TD312, BBWs, PD114, and PB211, are similarly effective in reducing oviposition.

Kogan and Ortman (1978) noted that resistant plants can produce allelochemicals with repellent properties ***to deter pests. Similarly, Mawan et al. (2013) demonstrated that treating rice***

seeds with Nigrospora sp. reduced both egg-laying and egg-hatching rates of the white-backed planthopper. Hendra et al. (2023) also reported that B. bassiana applied to rice seeds decreased the number of eggs laid by brown planthopper females. Furthermore, Prayogo et al. (2023) observed that colonization of B. bassiana in shallot tissues influenced oviposition preference in S. exigua, resulting in fewer eggs laid and lower hatch rates compared to the control (Figure 1).

Figure 1. *Bemisia tabaci* eggs on tomato plant leaves

B. tabaci Nymph Population

The seed-soaking application of B. bassiana to tomato plants significantly affected the number of B. tabaci nymphs. Analysis of variance confirmed that treatments with B. bassiana isolates resulted in a statistically significant decrease in nymph counts compared to the control. The mean number of B. tabaci nymphs per plant at five weeks after planting is shown in Table 2.

Table 2. Average Number Of *Bemisia Tabaci* Nymphs On Tomato Plants Treated With *Beauveria Bassiana* Isolates At 5 Weeks After Planting

Treatment	Nymph/plant) ± SE
Control	22.15 ± 7.69 a
PD114	14.65 ± 4.50 ab
BBWs	12.50 ± 2.19 ab
PB211	12.25 ± 3.00 ab
PA221	9.10 ± 2.74 b
TD312	7.25 ± 1.31 b

Note: Means within the same column followed by the same lowercase letter are not significantly different according to LSD at the 5% level.

All *B. bassiana* treatments reduced nymph populations compared to the control, though not all reductions were statistically significant (Table 2). PD114 had the highest nymph count among treated plants (14.65 per plant), while TD312 had the lowest (7.25 per plant).

Statistical analysis showed that PD114, BBWs (12.50), and PB211 (12.25) were not significantly different from the control. In contrast, PA221 (9.10) and TD312 (7.25) were significantly lower than the control. However, PA221 and TD312 were statistically similar to PD114, BBWs, and PB211.

These findings indicate that while all isolates suppressed nymph populations to some extent, only PA221 and TD312 demonstrated significant suppression compared to the control, with TD312 showing the numerically lowest nymph count.

Figure 2. *Bemisia* nymph on a tomato plant leaf

The lower population of *B. tabaci* nymphs on *B. bassiana*-treated tomato plants can be attributed to a reduction in egg laying by adult females, as well as a decreased egg hatching rate. The application of *B. bassiana* likely contributes to both factors by producing repellent compounds within colonized plant tissues, which deter oviposition and interfere with embryonic development. According to Flawerina (2021), *B. bassiana* can establish endophytic colonization in tomato plants, inhabiting roots, stems, and leaves, with the highest colonization observed in leaf tissues. This internal presence of *B. bassiana* has been shown to reduce pest populations and enhance plant resistance to insect pests under field conditions (Saragih et al., 2018). In support of this, Abdullah et al. (2020) reported that rice plants treated with *B. bassiana* via seed soaking experienced mortality of *Nephotettix virescens*, further demonstrating the fungus's potential to suppress pest populations through endophytic activity.

Population of *B. tabaci* adult

The application of the fungus *B. bassiana* reduced the number of *B. tabaci* adults on tomato plants compared to control plants. Analysis of variance results showed that all tested isolates were significantly different from the control. The population of *B. tabaci* adults on tomato plants, aged 5 weeks after planting (WAP), is shown in Table 3.

Table 3. Average number of *Bemisia tabaci* adults on tomato plants to which the application of *Beauveria bassiana* fungus at the age of 5 WAP

Treatment	Adult/plant) ± SE
Control	10.00 ± 1.90 a
PA221	5.35 ± 1.96 b
BBWs	3.75 ± 0.53 b
PB211	3.70 ± 0.50 b
PD114	3.45 ± 0.76 b
TD312	2.30 ± 0.37 b

Note: Numbers followed by the same lowercase letter in the same column are not significantly different according to LSD at the 5% level.

All *B. bassiana* treatments significantly reduced *B. tabaci* adult populations compared to the control (Table 3). Although TD312 showed the numerically lowest adult count (2.30 per plant), it was statistically similar to PA221 (5.35), BBWs (3.75), PB211 (3.70), and PD114 (3.45). These results indicate that all isolates are equally effective at suppressing adult *B. tabaci populations*. The morphology of *B. tabaci* adults is shown in Figure 3.

Figure 3. Adults of *Bemisia tabaci* on tomato leaves

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The study results indicate that treating tomato seeds with *B. bassiana* enhanced plant resistance against *B. tabaci*. This was demonstrated by lower nymph and adult populations observed across the four *B. bassiana* isolate treatments compared to the control. The reduced nymph population is attributed to decreased egg deposition, while the adult population was also suppressed in *B. bassiana*-treated plants. Seed treatment with *B. bassiana* enhanced tomato resistance against *B. tabaci*. All isolates significantly reduced egg and adult populations, while only PA221 and TD312 significantly suppressed nymphs. TD312 consistently showed the lowest numerical pest counts across all stages, though statistically similar to several other isolates. These findings support previous studies (Trizelia et al., 2020) on the effectiveness of *B. bassiana*, particularly isolate TD312, in suppressing pest populations through endophytic colonization and induced resistance. Hendra et al. (2023) observed that B. bassiana application to rice seeds reduced the percentage of brown planthopper adults. Additional studies support these results: Akello et al. (2008) found that soaking banana roots in *B. bassiana* reduced *Cosmopolites sordidus* populations by up to 88.9% and plant damage by 86.7%, and Saragih (2024) reported that *B. bassiana* applications suppressed the population growth and attack intensity of *B. tabaci*, *M. persicae*, and *Aphis gossypii* on chili plants. Overall, *B. bassiana* colonizing plant tissues can indirectly induce resistance to insect pests.

The protective mechanism of endophytic fungi against pests may involve qualitative and quantitative changes in plant nutrition—such as alterations in carbohydrate, nitrogen, and phytosterol content (Grabka et al., 2022)—as well as morphological and physiological modifications in the plant (Gao et al., 2010). Inoculation with *B. bassiana* can elevate the levels of various defense-related compounds, including ethylene, chitinase, phytoalexins, alkaloids, jasmonic acid, and salicylic acid, which are critical in pest development (Vlot et al., 2009). For instance, Hendra (2022) reported that *B. bassiana* treatment in rice increased salicylic acid and oxalic acid content while reducing sucrose levels in stems. Salicylic acid is essential for plant defense against pests (Moran & Thompson, 2001), and oxalic acid inhibits phloem feeding by planthoppers and is toxic to insects at high concentrations (Korth et al., 2006). According to Yoshihara et al. (1980), oxalic acid is a key factor in rice resistance to planthoppers. Endophytic *B. bassiana* can also be directly toxic to insects by producing feeding deterrents or antibiotics (Bing and Lewis, 1992; Vega et al., 2008).

Antibiosis is one mode of action in which ingested plant tissues or fluids adversely affect insects, leading to mortality, growth reduction, developmental failure, or behavioral abnormalities (Fatahuddin et al., 2003). *B. bassiana* exhibits antibiosis by producing compounds that inhibit pest growth and development, often through the induction of plant secondary metabolites such as alkaloids, flavonoids, terpenoids, phenolics, and toxins (Schulz et al., 1999). Its secondary metabolites can act as bioinsecticides, disrupting insect metabolism and immune responses (Ávila-Hernández et al., 2020). Azevedo et al. (2000) linked pest control effects to the toxin-producing capacity of endophytes, and Calhoun et al. (1992) demonstrated that endophytic fungi synthesize toxins that inhibit *Choristoneura fumifera* growth. Additionally, endophytes can indirectly enhance resistance by stimulating the production of defense-signaling compounds, such as salicylic acid, jasmonic acid, and ethylene (Gao et al., 2010).

Trichome Density in Tomato Plants

Application of *B. bassiana* through seed soaking significantly influenced trichome density on tomato leaves (Table 4). TD312 showed the numerically highest trichome density (616.73 per cm²), followed by PA221 (597.66), BbWs (507.13), PD114 (439.26), and PB211 (392.40), while the control had the lowest density (295.73).

Table 4. Number of trichomes on tomato plant leaves

Treatment	Trichome Density (cm^2) ± SE
TD312	616.73 ± 81.71 a
PA221	597.66 ± 60.63 a
BbWs	507.13 ± 82.58 ab
PD114	439.26 ± 56.26 abc
PB211	392.40 ± 28.43 bc
Control	295.73 ± 33.79 c

Note: Means within the same column followed by the same lowercase letter are not significantly different according to LSD at the 5% level.

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B. bassiana application significantly affected trichome density on tomato leaves (Table 4). TD312, PA221, BbWs, and PD114 showed significantly higher trichome density than the control, with TD312 and PA221 having the highest numerical values. These four isolates were statistically similar to each other. PB211 had moderate trichome density, statistically similar to both PD114 and the control. Enhanced trichome density, particularly in TD312, PA221, BbWs, and PD114, may strengthen plant physical barriers against *B. tabaci*

The influence of *B. bassiana* on plant morphology, including increased trichome density, is likely due to its endophytic colonization, which may stimulate the production of plant growth regulators such as auxin, cytokinin, and gibberellin. According to Halo et al. (2023), endophytic fungi can increase trichome density on tomato leaves by secreting gibberellins, thereby enhancing drought resistance. Similarly, Qin et al. (2021) reported that *B. bassiana* colonization in tobacco plants promotes growth by enhancing photosynthetic rate, chlorophyll content, and trichome and stomatal density. High trichome density is a key physical trait associated with pest resistance, as dense trichomes can impede *B. tabaci* females from penetrating the leaf epidermis and inserting their stylets to feed. Consequently, leaves with dense trichomes are less preferred for oviposition and feeding. In this study, tomato plants treated with *B. bassiana* isolates showed higher trichome density and lower adult *B. tabaci* populations compared to the control. This aligns with findings by Flawerina (2021), who reported that increased trichome density in tomato plants enhances resistance to *B. tabaci* infestations.

CONCLUSION

Seed treatment of tomato plants with Beauveria bassiana effectively suppressed Bemisia tabaci populations. Isolate TD312 resulted in the lowest populations of eggs (20.40 per plant), nymphs (7.25 per plant), and ***adults (2.30 per plant) compared to the control (81.10, 22.15, and 10.00 per plant, respectively). Additionally, application of B. bassiana affected plant morphology by increasing trichome density. TD312 isolates increased trichome density to 616.73/cm²*** ***, which was higher than the control (295.73/cm*** ***), potentially enhancing antixenosis (non-preference) mechanisms against B. tabaci. Although statistically comparable to several other isolates on some parameters, TD312 consistently exhibited the lowest pest counts and the highest trichome density, indicating its potential to enhance tomato resistance to B. tabaci by suppressing pest populations and reinforcing trichome density. Further studies are needed to investigate the secondary metabolites involved in induced resistance.***

ACKNOWLEDGMENT

Thanks are extended to Andalas University for funding this research through a Bachelor's Thesis Research grant with Contract No. 269/UN16.19/PT.01.03/PSS/2024, which enabled this research to run smoothly.

REFERENCE

Akello, J., Dubois, T., Coyne, D., & Kyamanywa, S. (2008). Endophytic Beauveria bassiana in banana (Musa spp.) reduces banana weevil (Cosmopolites sordidus) fitness and damage. Crop Protection, *27*(11), 1437–1441. https://doi.org/10.1016/j.cropro.2008.07.003

Abdullah, T., Kuswinanti, T., Nurariaty, A., Daud, I.D., Nasruddin, A., Risal, R., & Tuwo, M. (2020). Application of *Beauveria bassiana* (Bals.) Vuill. (Hypocreales: Cordycipitaceae) in rice seed and its effect on the mortality of green leaf hopper, *Nephotettix virescens* (Distant) (Homoptera: Cicadellidae). *IOP Conference Series: Earth and Environmental Science, 486*, 012150.

Agastya, I.M.I., Julianto, R.P.D., & Marwoto. (2020). Pengaruh pemanasan global terhadap intensitas serangan kutu kebul (*Bemisia tabaci* Genn) dan cara pengendaliannya pada tanaman kedelai. *Buana Sains, 20*(1), 99–110.

Ávila-Hernández, J.G., Carrillo-Inungaray, M.L., Cruz-Quiroz, R.D., Wong-Paz, J.E., Muñiz-Márquez, D.B., Parra, R., Aguilar, C.N., & Aguilar-Zárate, P. (2020). *Beauveria bassiana* secondary metabolites: a review inside their production systems, biosynthesis, and bioactivities. *Mexican Journal of Biotechnology, 5*(4), 1–33.

Azevedo, J.L., Maccheroni, W. Jr., Pereira, J.O., & de Araujo, W.L. (2000). Endophytic microorganisms: a review on insect control and recent advances on tropical plants. *Electronic Journal of Biotechnology, 3*, 40-65.

Bamisile, B.S., Dash, C.K., Akutse, K.S., Keppanan, R., Afolabi, O.G., Hussain, M., Qasim, M., & Wang, L. (2018). Prospects of endophytic fungal entomopathogens as biocontrol and plant growth promoting agents: an insight on how artificial inoculation methods affect endophytic colonization of host plants. *Microbiological Research*. https://doi.org/10.1016/j.micres.2018.08.016

Batool, R., Umer, M.J., Wang, Y., He, K., Zhang, T., Bai, S., Zhi, Y., Chen, J., & Wang, Z. (2020). Synergistic Effect of *Beauveria bassiana* and *Trichoderma asperellum* to induce maize (*Zea mays* L.) defense against the Asian corn borer, *Ostrinia furnacalis* (Lepidoptera, Crambidae) and larval immune response. *International Journal of Molecular Sciences, 21*, 8215. https://doi.org/10.3390/ijms21218215

Bing, L.A., & Lewis, L.C. (1992). Evidence for feeding deterrence and antibiosis of endophytic *Beauveria bassiana* against insect herbivores. *Environmental Entomology*.

Calhoun, L.A., Jhon, A., Findlay, J., David, M., & Norman, J.W. (1992). Metabolites toxic to spruce budworm balsam fir needle endophyte. *Mycological Research, 96*(4), 281-286.

Earsakul, S., Pornsopin, N., Techawongstien, S., Lapjit, C., Jeeatid, N., Suwor, P., Nawae, W. & Tarinta, T. (2025). Characterizing the density and type of leaf trichomes in tomato for resistance to yellow leaf curl disease. SABRAO Journal of Breeding and Genetics, 57(5), 2069-2079. https://doi.org/10.54910/sabrao2025.57.5.27

Erdiansyah, E., Suwardi, S., & Wulandari, G. (2023). *Beauveria bassiana* untuk pengendalian *Bemisia tabaci* pada budidaya kedelai organik. *Agrotechnology Research Journal, 7*(2), 79–84.

Fatahuddin, A.N., Daud, I.D., & Chandra, Y. (2003). Uji Kemampuan *Beauveria bassiana* Vuillemin (Hyphomycetes: Moniliales) sebagai endofit pada tanaman kubis dan pengaruhnya terhadap larva *Plutella xylostella* (Lepidoptera: Yponomeutidae). Universitas Hasanuddin.

Flawerina, G. (2021). *Penggunaan cendawan entomopatogen Beauveria bassiana (Balsamo) Vuill. untuk pengendalian Bemisia tabaci (Gennadius) (Hemiptera; Aleyrodidae) pada tanaman tomat* [Tesis]. Universitas Andalas.

Gao, F.K., Dai, C.C., & Liu, X.Z. (2010). Mechanisms of fungal endophytes in plant protection against pathogens. *African Journal of Microbiology Research, 4*(13), 1346-1351.

Gautam, S., Mohankumar, S., & Kennedy, J.S. (2016). Induced host plant resistance in cauliflower by *Beauveria bassiana*. *Journal of Entomology and Zoology Studies, 4*(2), 476-482.

González-Guzmán, A., Sánchez-Rodríguez, A.R., Quesada-Moraga, E., Del Campillo, M.C. & Yousef-Yousef, M. (2021). Optimizing wheat seed treatment with entomopathogenic fungi for improving plant growth at early development stages. Spanish Journal of Agricultural Research, 19(4), e1004. https://doi.org/10.5424/sjar/2021194-17564

Grabka, R., d'Entremont, T. W., Adams, S. J., Walker, A. K., Tanney, J. B., Abbasi, P. A., & Ali, S. (2022). Fungal Endophytes and Their Role in Agricultural Plant Protection against Pests and Pathogens. Plants, 11(3), 384. https://doi.org/10.3390/plants11030384

Gullino, M.L., Garibaldi, A., Gamliel, A. & Katan, J. (2022). Soil Disinfestation: From Soil Treatment to Soil and Plant Health. Plant Disease, 106(6), 1541-1554. https://doi.org/10.1094/PDIS-09-21-2023-FE

Halo, B.A., Al-Yahyai, R., Al-Sadi, A., & Al-Sibani, A. (2023). Desert endophytic fungi improve reproductive, morphological, biochemical, yield and fruit quality characteristics of tomato under drought stress. *Arab Gulf Journal of Scientific Research, 41*(4), 638-655.

Hidayat, P., Ludji, R., & Maryana, N. (2020). Kemampuan reproduksi dan riwayat hidup kutu kebul *Bemisia tabaci* (Gennadius) dengan dan tanpa kopulasi pada tanaman cabai merah dan tomat. *Jurnal Entomologi Indonesia, 17*(3), 156–162.

Horowitz, A.R., Ghanim, M., Roditakis, E., Nauen, R., & Ishaaya, I. (2020). Insecticide resistance and its management in *Bemisia tabaci* species. *Journal of Pest Science, 93*, 893–910.

Hendra, Y., Ulpah, S., Trizelia, Syahrawati, M., & Saragih, M. (2026). Triple functional roles of endophytic fungi in pest management: a systematic review. Egyptian Journal of Biological Pest Control, 36(1), 1. https://doi.org/10.1186/s41938-025-00874-z

Hendra, Y., Trizelia, & Syaharawati, M. (2022). Virulensi empat isolat *Beauveria bassiana* Bals. Vuill terhadap wereng batang coklat (*Nilaparvata lugens* Stal.). *Jurnal Pertanian Agros, 24*(2), 552-558.

Hendra, Y. (2022). *Induksi ketahanan tanaman padi terhadap wereng batang coklat (Nilaparvata lugens Stal) menggunakan cendawan entomopatogen Beauveria bassiana (Bals.) Vuill* [Tesis]. Universitas Andalas.

Hendra, Y., Trizelia, & Syahrawati, M. (2023). Colonization of the entomopathogenic fungus *Beauveria bassiana* (Bals.) Vuill. on rice and its impact on nymph mortality and fecundity of brown planthopper (*Nilaparvata lugens* Stål). *Jurnal Entomologi Indonesia, 20*(3), 203. https://doi.org/10.5994/jei.20.3.203

Ibrahima, C., Kaili, C., Rouguiatou, S., Peipei, W., Wangpeng, S. & Shuqian, T. (2022). Screening of *Beauveria bassiana* (Bals.) (Hypocreales: Cordycipitaceae) strains against Megalurothrips usitatus (Bagnall) (Thysanoptera: Thripidae) and conditions for large-scale production. Egyptian Journal of Biological Pest Control, 32(1), 85. https://doi.org/10.1186/s41938-022-00584-w

Inayati, A., & Marwoto. (2015). Kultur teknis sebagai dasar pengendalian hama kutu kebul *B. tabaci* Genn pada tanaman kedelai. *Buletin Palawija, 29*, 14-25.

Kessler, A., & Baldwin, I.T. (2002). Plant responses to insect herbivory: the emerging molecular analysis. *Annual Review of Plant Biology, 53*, 299–328. https://doi.org/10.1146/annurev.arplant.53.100301.135207

Kogan, M., & Ortman, E.E. (1978). Antixenosis – a new proposed term to replace Painter's "nonpreference" modality of resistance. *Bulletin of the Entomological Society of America, 24*, 175-176.

Korth, K.L., Doege, S.J., Park, S.H., Goggin, F.L., Wang, Q., Gomez, S.K., Liu, G., Jia, L., & Nakata, P.A. (2006). *Medicago truncatula* mutants demonstrate the role of plant calcium oxalate crystals as an effective defense against chewing insects. *Plant Physiology, 141*, 188–195. https://doi.org/10.1104/pp.106.076737

Kumar, P., Sharma, S. & Singh, R. (2023). Diurnal activity patterns of Bemisia tabaci and implications for sampling accuracy in tomato crops. Crop Protection, 168, 106212. https://doi.org/10.1016/j.cropro.2023.106212

Mawan, A., Damayanti, B., & Hermanu, T. (2013). Pengaruh cendawan endofit terhadap biologi dan statistik demografi wereng batang coklat *Nilaparvata lugens* Stal (Hemiptera: Delphacidae). *Jurnal Entomologi Indonesia, 12*(1), 11-19.

Melo, A.P.C., Silva, T.C., Oliveira, F.A. & Santos, M.G. (2024). Organic substrates and irrigation frequencies affect tomato seedling quality for sustainable production. Horticulturae, 10(2), 145. https://doi.org/10.3390/horticulturae10020145

McCormick, A., Reinecke, A., & Gershenzon, J. (2016). Feeding experience affects the behavioral response of polyphagous gypsy moth caterpillars to herbivore-induced poplar volatiles. *Journal of Chemical Ecology, 42*(5), 382–393.

Mota-Sanchez, D., & Wise, J.C. (2019). *The arthropod pesticide resistance database*. Michigan State University. http://www.pesticideresistance.org

Moran, P.J., & Thompson, G.A. (2001). Molecular responses to aphid feeding in Arabidopsis in relation to plant defense pathways. *Plant Physiology, 125*, 1074–1085.

Pandey, V., Gupta, S., Mishra, A. & Kumar, R. (2023). Seed priming with microbial consortia enhances germination and seedling vigor in tomato (Solanum lycopersicum L.) under protected cultivation. Scientia Horticulturae, 312, 111845. https://doi.org/10.1016/j.scienta.2023.111845

Posada, F., & Vega, F.E. (2005). Establishment of the fungal entomopathogen *Beauveria bassiana* (Ascomycota: Hypocreales) as an endophyte in cocoa seedlings (*Theobroma cacao*). *Mycoscience, 47*(5), 284-289.

Prayogo, Y., Bayu, M.S.Y.I., Indiati, S.W., Sumartini, Susanto, G.W.A., Harnowo, D., Baliadi, Y., Widiarta, I.N., Harsono, A., Budiono, R., Mejaya, M.J., & Supriadi, K. (2023). Control measure of sweet potato weevil (*Cylas formicarius* Fab.) (Coleoptera: Curculionidae) in endemic land of entisol type using mulch and entomopathogenic fungus *Beauveria bassiana*. *Open Agriculture*. https://doi.org/10.1515/opag-2022-0237

Qin, X., Zhao, X., Huang, S., Deng, J., Li, X., Luo, Z., & Zhang, Y. (2021). Pest management via endophytic colonization of tobacco seedlings by the insect fungal pathogen *Beauveria bassiana*. *Pest Management Science, 77*(4), 2007-2018.

Razak, N.A., Nasir, B., & Khasanah, N. (2016). Efektifitas *Beauveria bassiana* Vuill terhadap pengendalian *Spodoptera exigua* Hubner (Lepidoptera: Noctuidae) pada tanaman bawang merah lokal Palu (*Allium wakegi*). *e-Jurnal Agrotekbis, 4*(5), 565-570.

Saragih, M., Trizelia, Nurbailis, & Yusniwati. (2018). Endophytic colonization and plant growth promoting effect by entomopathogenic fungus, *Beauveria bassiana* to red chili (*Capsicum annuum* L.) with different inoculation methods. *IOP Conference Series: Earth and Environmental Science, 305*, 012070.

Saragih, M., Trizelia, Nurbailis, & Yusniwati. (2019). Endophytic colonization and plant growth promoting effect by entomopathogenic fungus, *Beauveria bassiana* to red chili (*Capsicum annuum* L.) with different inoculation methods. *IOP Conference Series: Earth and Environmental Science, 305*, 012070. https://doi.org/10.1088/1755-1315/305/1/012070

Saragih, M. (2024). *Aplikasi cendawan Beauveria bassiana (Balsamo) Vuillemin untuk menginduksi ketahanan tanaman cabai (Capsicum annuum L.) terhadap kutu kebul (Bemisia tabaci Genn.) dan kutu daun (Myzus persicae Sulz. dan Aphis gossypii Glov.)* [Disertasi]. Universitas Andalas.

Schulz, B., Römmert, A.-K., Dammann, U., Aust, H.-J., & Strack, D. (1999). The endophyte-host interaction: a balanced antagonism? Mycological Research, 103(10), 1275‑1283. https://doi.org/10.1017/S0953756299008540

Siahaan, P., Wongkar, J., Wowiling, S., & Mangais, R. (2021). Patogenisitas *Beauveria bassiana* (Bals.) Vuill. yang diisolasi dari beberapa jenis inang terhadap kepik hijau, *Nezara viridula* L. (Hemiptera: Pentatomidae). *Jurnal Ilmiah Sains, 21*(1), 26-33.

Singh, R., Kumar, P. & Sharma, M.K. (2022). Effect of growing media and seedling age on quality parameters of tomato (Solanum lycopersicum L.) seedlings. Journal of Plant Nutrition, 45(8), 1189-1200. https://doi.org/10.1080/01904167.2021.2006703

Smith, H.A., Nagle, C.A., MacVean, C. & Vallad, G.E. (2024). Standardized sampling protocols for Bemisia tabaci in vegetable crops under protected cultivation. Journal of Pest Science, 97, 215-228. https://doi.org/10.1007/s10340-023-01680-2

Sofwah, A., & Prastowo, S. (2023). Efektivitas *Beauveria bassiana* dan *Metarhizium anisopliae* terhadap pengendalian hama Thrips sp. (Thysanoptera: Tripidae) pada tanaman cabai besar (*Capsicum annuum* L.). *Berkala Ilmiah Pertanian, 6*(3), 115-121.

Soumia, P.S., Pandi, G.P., Krishna, R., Ansari, A.W., Jaiswal, D.K., Verma, J.P., & Singh, M. (2021). Whitefly-transmitted plant viruses and their management. In K.P. Singh, S. Jahadigar, & B.K. Sarma (Eds.), *Emerging Trends in Plant Pathology* (pp. 175–195). Springer.

Sugiyama, K. (2005). Management of whitefly for commercial tomato production in greenhouses in Shizuoka, Japan. In T.Y. Ku & C.L. Wang (Eds.), *Proceedings of the International Seminar on Whitefly Management and Control Strategy* (pp. 81–91). Taichung, Taiwan.

Trizelia, & Nurdin, F. (2010). Virulence of entomopathogenic fungus *Beauveria bassiana* isolates to *Crocidolomia pavonana* F (Lepidoptera: Crambidae). *Jurnal Agrivita, 32*(3), 254-260.

Trizelia, T. (2020). The effect of seed treatment duration with entomopathogenic fungi *Beauveria bassiana* on seed germination and seedling growth of chili. *JERAMI: Indonesian Journal of Crop Science, 3*(1), 25–29. https://doi.org/10.25077/jijcs.3.1.25-29.2020

Trizelia, Martinus, Reflinaldon, Yenny, L., & Fadly, S.P. (2020). Colonization of *Beauveria bassiana* (Bals.) Vuill on chilli (*Capsicum annum*) and its effect on populations of *Myzus persicae*. *Journal of Biopesticides, 13*(1), 40-46.

Trizelia, Reflin, & Ananda, W. (2016). Virulensi beberapa isolat cendawan entomopatogen endofit *Beauveria bassiana* Bals. terhadap *Spodoptera litura* F. (Lepidoptera: Noctuidae). *Prosiding Seminar Nasional BKS PTN Wilayah Barat Bidang Ilmu Pertanian*, 409-415.

Vega, F.E. (2018). The use of fungal entomopathogens as endophytes in biological control: a review. *Mycologia, 110*(1), 4–30. https://doi.org/10.1080/00275514.2017.1418578

Vega, F.E., Posada, F., Aime, M.C., Pava-Ripoll, M., Infante, F., & Rehner, S.A. (2008). Entomopathogenic fungal endophytes. *Biological Control, 46*(1), 72–82. https://doi.org/10.1016/j.biocontrol.2008.01.008

Vlot, A.C., Dempsey, D.A., & Klessing, D.F. (2009). Salicylic acid, a multifaceted hormone to combat disease. *Annual Review of Phytopathology, 47*(1), 177-206.

Xu, J., Yao, J., Zhai, H., Li, Q., Xu, Q., Xiang, Y., Liu, Y., Liu, T., Ma, H., Mao, Y., Wu, F., Wang, Q., Feng, X., Mu, J. & Lu, Y. (2023). TrichomeYOLO: A neural network for automatic maize trichome counting. Plant Phenomics, 5, 0024. https://doi.org/10.34133/plantphenomics.0024

Yoshihara, T., Pathak, M.D., Juliano, B.O., & Sakamura, S. (1980). Oxalic acid as a sucking inhibitor of the brown planthopper in rice (Hemiptera: Delphacidae). *Entomologia Experimentalis et Applicata, 27*, 149-155.

Zhang, L. (2014). *Colonization pattern of crop plants by endophytic fungi* [Disertasi]. Georg August University Göttingen.