Journal of Agriculture (JoA)
Volume: 4 | Number 02 | July 2025
E-ISSN: 2829-2421
https://doi.org/10.47709/joa.v4i02.6542

Utilization of *Beauveria Bassiana* Bals.-Criv. Fungus to Control Coffee Berry Borer (*Hypothenemus Hampei F.)* Invitro

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Received: 2025-07-17
Accepted: 2025-07-25
Publication: 2025-07-25

Abstract
Coffee (*Coffea sp*) is one of the most important plantation commodities in Indonesia, largely due to its considerable economic value. However, coffee production faces significant challenges from pests such as the coffee berry borer (PBKo) (*Hypothenemus hampei* F), which can cause severe damage to crops, with losses reaching up to 100%. Biological control agents, particularly the entomopathogenic fungus *Beauveria bassiana,* have gained increasing attention as environmentally friendly alternatives to chemical pesticides. While the efficacy of *B. bassiana* against *H. hampei* has been widely documented, most previous studies have primarily targeted the adult or larval stages, often overlooking the differences in susceptibility among the various metamorphosis phases. This study addresses this research gap by systematically evaluating the effectiveness of *B. bassiana* as a biological control agent against PBKo across each stage of the pest's metamorphosis-egg, larva, pupa, and imago-under in vitro conditions. Using a controlled experimental design, we assessed mortality rates in each developmental phase after exposure to *B. bassiana* treatment. The findings of this study are expected to provide comprehensive insights into the phase-specific efficacy of *B. bassiana,* identifying which metamorphic stage is most vulnerable to fungal infection. This knowledge is anticipated to improve biological control strategies, ultimately supporting more targeted and sustainable integrated pest management practices for coffee plantations. These advancements can enhance coffee yields and quality while reducing reliance on synthetic chemical pesticides.

Keywords: *Beauveria Bassiana;* Biological Control; Coffee Berry Borer (CBB); Coffee Productivity; Control; Effectiveness

Introduction

Coffee (*Coffea sp*) is a type of plantation crop that is widely cultivated by the community because it has a fairly high economic value. Arabica coffee contributes 70% of world consumption, and the remaining 30% comes from Robusta coffee. Coffee originally came from Africa, namely the Euterpe mountains. Only after developing in southern Yemen, Arabia, did coffee begin to be known (Rahardjo P, 2012). According to the Indonesian Central Statistics Agency in 2023, the area of coffee plantations in Indonesia reached 1,268.9 hectares, consisting of state-owned plantations (PBN) covering an area of 19,800 hectares and community plantations covering an area of 1,249.1 hectares. Along with the expansion of coffee plantations, Indonesian coffee production has actually decreased in the last two years. According to the 2023 Indonesian Central Statistics Agency Report, Indonesian coffee production reached 775,000 tons in 2022, down 14,800 tons from 2019. In recent years, Indonesia's highest coffee production occurred in 2021 (Badan Pusat Statistik, 2024). However, coffee production in several coffee production centres in Indonesia is experiencing a downward trend caused by several things, such as reduced coffee

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plantation area, pest and disease attacks, and climate change (Badan pusat statistik, 2020); (Syakir & Surmaini, 2017); (Wahyudi et al., 2018).

Low yields and low-quality coffee are the main problems faced by coffee plantations in Indonesia. According to(Girsang et al., 2020). The attack of coffee berry borer pests (*Hypothenemus hampei* F.) is one of the factors that limits coffee production, besides also causing a decrease in coffee quality. PBKo is an invasive pest that has caused damage to coffee plants ranging from 10% - 40% or even up to 100% (Lee et al., 2023). Coffee berries infected with PBKo pests are damaged, both in the skin of the coffee berries, to the coffee beans, young berries fall off and can cause losses in both quantity and quality (Johnson et al., 2020); (Erfandari & Supriyatdi, 2019). PBKo pest control prioritizes the Integrated Pest Management (IPM) approach with a natural control strategy (Francisco Infante, 2018). Efforts to control PBKo pests are very difficult because they live almost their entire life in the coffee berries. One of the options for controlling PBKo pests that is expected to be effective is natural control technology using natural enemies including groups of parasitic insects, predatory insects, and entomopathogenic fungi.

Natural control can be done by using natural control agents such as entomopathogenic fungi. One of the entomopathogenic fungi that has the potential to be used as a control agent for PBKo pests is the *Beauveria bassiana* fungus, which is an insect pathogen and is often used to manage PBKo pests, both as a natural agent and a microbial bioinsecticide (Hollingsworth et al., 2020).

Therefore, this study aims to increase knowledge about the Effectiveness of *Beauveria bassiana* Bals.-Criv. Fungus in controlling Coffee Berry Borer Pests (*Hypothenemus hampei* F.) In-Vitro, with a focus on application on the Metamorphosis Phase of the pest, namely the Egg Phase, Larva Phase, Pupa Phase, and Imago/adult Phase, so that it can provide more specific information about which phase is most susceptible to fungal infection and how this fungus can be used effectively in pest control in-vitro.

Literature Review

Coffee berry borer (*Hypothenemus hampei* F.) is a major pest that significantly reduces coffee productivity and quality in Indonesia, with damage levels that can reach 40% to 100% of coffee berries (Lee et al., 2023; Warlinson Girsang et al., 2020). Controlling this pest remains a major challenge because its entire life cycle takes place inside the coffee berry, limiting the effectiveness of chemical insecticides and posing environmental risks (Francisco Infante, 2018; Johnson et al., 2020). Therefore, a biological control approach using entomopathogenic fungi such as *B.bassiana* is a promising alternative (Hollingsworth et al., 2020); Bayu et al., 2021).

Beauveria bassiana Bals.-Criv. It has the potential to show greater toxicity and is specific to the environment. The fungal inoculum will develop inside the host's body and pose no harm to natural enemies and the environment. The host of the *fungus Beauveria bassiana* Bals.-Criv includes the orders Homopteran, Hemiptera, Orthopteran, Coleoptera, Lepidoptera, Diptera, Isoptera and Hymenoptera and does not cause resistance in the target insects. then attacks all body tissues from the inside so that the insect dies (Nurul Dyah Parasmita et al., 2024; Bayu et al., 2021).

Although the effectiveness of *B.bassiana* against *H.hampei* has been widely reported, most studies are still limited to testing the adult or larval stages in general without distinguishing the response of each metamorphosis phase specifically (Marleni et al., 2013; Silviani et al., 2023). In fact, different physiological and morphological characteristics in the egg, larva, pupa, and imago stages can affect the level of susceptibility to fungal infections (Chuquibala-Checan et al., 2023; Bayman et al., 2021). Marleni et al., (2013) showed that *B.bassiana* fungus was effective in controlling *H.hampei* on Arabica coffee beans with the highest percentage of imago mortality reaching 71.66%. Batta, (2018)wrote that the use of *B.bassiana* fungus on *S. Granarius* imago with wheat flour media resulted in 100% pest mortality on the 10th day after application. Followed

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by Silviani et al., (2023) who wrote that the *B.bassiana* fungus can cause mortality of Cocoa fruit borer (*Conomorpha cramerella*) by 56.67% in the Pupa phase. This knowledge gap is an obstacle in optimizing the right and effective *B. bassiana* application strategy.

This study fills this gap by conducting in vitro tests that focus on evaluating *H.hampei* mortality at each metamorphosis phase (eggs, larvae, pupae, and imago) systematically. This approach is the main novelty that distinguishes this study from previous studies, because it explicitly examines the sensitivity of each phase of pest development to *B.bassiana*, so that it can identify the most vulnerable phase and provide a scientific basis for the development of more efficient and sustainable biological control.

This study aims not only to broaden the understanding of the dynamics of *B.bassiana* pathogenicity against *H.hampei*, but also to provide a strategic contribution to the management of coffee pests based on more targeted and environmentally friendly biocontrol.

Research Method

This research was conducted at the Pest and Disease Laboratory, Faculty of Science and Technology, Universitas Pembangunan Panca Budi, Medan, North Sumatra. The research was conducted from January to May 2025. The tools used in this study include: jars, plastic, gauze, plastic wrap, label paper, aluminium foil, magnifying glass, cutter ruler, hands prayer, electronic scales, microscope, freezer, microwave, autoclave, laminar air flow, incubator, computer/laptop, rotary mixer, measuring cup, Erlenmeyer flask, stirrer, petri dish, Ose needle, fine brush, slide glass. The materials used in this study were: isolates of *Beauveria bassiana* Bals.-Criv. fungus from the Centre for Plantation Plant Protection (BBPPTP), specimens of *Hypothenemus hampei* F. pests on Arabica coffee cherries, *Potato Dextrose Agar* (PDA) media, 70% alcohol, spirits and distilled water.

This study uses an experimental method in the Laboratory with treatment at the Metamorphosis phase using a Completely Randomized Design (CRD) NON-Factorial to determine the effectiveness of the *B.bassiana* fungus. In inhibiting the development of Coffee Berry Borer Pests (PBKo) (*Hypothenemus hampei* F.) in vitro. There are 5 treatments in this test, each tested by applying the *B.bassiana* fungus. Which has been homogenized 101 control (without fungus application) and repeated 3 times. The treatments consist of: P0 (Control), P1 (Egg Phase), P2 (Larva Phase), P3 (Pupa Phase), P4 (Imago/adult Phase). Each treatment uses 10 Coffee Berry Borer (*Hypothenemus hampei* F.)

Research steps taken:

Sterilization of tools and media is a fundamental stage in fungal research to prevent contamination of microorganisms. This process is generally carried out by autoclaving at a temperature of 121°C for 15–20 minutes, which has been proven to be effective in killing bacterial and fungal spores, as well as ensuring the success of in vitro culture (Wulandari et al., 2022). *Potato Dextrose Agar* (PDA) media was chosen because its nutritional content supports optimal growth and sporulation of *B.bassiana*, as evidenced by various studies showing that PDA media produces high mycelial and conidia growth (Octavia Kita Sipayung et al., 2023).

B.bassiana inoculation was carried out aseptically in a laminar air flow room to maintain sterility, then incubated at room temperature until the colonies filled the media. Periodic measurements of colony diameter were used to assess the rate of fungal growth. This technique has been validated as a standard method in the study of the growth and viability of entomopathogenic fungi (Gunawan et al., 2024). The test insect, namely the coffee berry borer (*Hypothenemus hampei* F), was collected from the field and maintained under controlled conditions to ensure the uniformity and health of the test individuals. A suspension of *B. bassiana* spores was prepared by

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homogenizing the mycelium in sterile water, then applied to the test insects by spraying. Observations were carried out daily to detect symptoms of infection and mortality, according to the standardized bioassay protocol in biological control research (MARIA RANI RAKA SIWI, 2022).

Results and Discussion

Inoculation of *Beauveria bassiana* Bals.-Criv fungus.

Inoculation of *B.bassiana* fungus on PDA (*Potato Dextrose Agar*) media with the aim of producing conidia which will later be used for biological control agents. PDA (*Potato Dextrose Agar*) is a commonly used medium for the growth of fungal colonies in the laboratory because the pH it has is low (pH 4.5 to 5.6) thus reducing the risk of bacterial contamination. PDA contains carbon (carbohydrates), vitamins and energy, dextrose as a source of sugar and energy. Each of these three components is essential for the growth and reproduction of microorganisms, especially fungi (Octavia et al., 2017).

Physical characteristics of *B.bassiana* fungal colonies were observed when the entire diameter of the petri dish was filled with fungi including umbonate elevation, irregular margin (erose), irregular whole colony and pale yellowish white hyphae. The morphological characteristics of the colony were positively correlated with the growth rate of the fungus. Research by Utami et al., (2014) showed that the Junrejo isolate had the largest conidia and conidium sizes and dense hyphae, resulting in a high percentage of death in a short time. The dusty colony texture had a higher growth rate compared to the chalky texture (Affandi et al., 2012).



Figure 1 & 2. Inoculation of Beauveria bassiana Bals.-Criv fungus on PDA (Potato Dextrose Agar) media

Diameter Colony

Based on the results of the research that has been done shows that the observations observed 10 days after inoculation of *B.bassiana* On PDA media. Measurement of the diameter of the fungal colony on the petri dish using the formula:

$$D = \frac{d1 + d2}{2}$$

Information:
d1= horizontal diameter of fungal colony (mm)
d2= vertical diameter of fungal colony (mm)
D= diameter of fungal colony (mm)
The observation data for calculating the diameter of the fungal colony are presented in Table 1.

Table 1. 1. Diameter of Growth of *B.bassiana* Fungal Colony.

Isolate	Day

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	Day 10	Day 20	Day 30	Day 40	Day 50
BBU1	26.6	48.55	56.65	60.5	75.95
BBU2	26.8	47.15	55.65	70.3	84.5
BBU3	40.05	53.4	62.55	66.25	77.65

BBU1- B.bassiana Repeat 1, BBU2- B.bassiana Repeat 2, BBU3- B.bassiana Repeat 3

Based on growth rate observation data for 50 days, there was significant variability among *B.bassiana* isolates. Isolate BBU2 showed superior growth performance with the fastest growth rate and largest colony diameter, followed by BBU1, while BBU3 showed the lowest growth rate with slower adaptation to culture media conditions. Intraspecific genetic diversity is the main factor influencing differences in growth rates among *B.bassiana* isolates. Recent studies have shown that genes involved in primary and secondary metabolism have different copy number variations (CNVs) and non-synonymous changes (NSCs) among isolates. Isolates with high genetic variation in lectin-like, mucin signalling, and chitinase genes tend to have more vigorous growth (Gasmi et al., 2021). Genetic polymorphisms in genes regulating energy biosynthesis and protein/amino acid turnover contribute to different metabolic efficiencies (Proietti et al., 2023). Isolate BBU2 likely has optimal gene expression for ATP synthesis and carbohydrate metabolism, thus achieving higher biomass in a shorter time compared to BBU1 and BBU3. Hydrolytic and proteolytic enzyme activities also contribute to growth efficiency. Romón et al., (2017) reported that isolates with high production of cutinise and protease enzymes are able to utilize media substrates more effectively, resulting in superior growth rates. Variation in BAS2 (biotrophy associated secreted gene 2) gene expression between isolates affects the ability to penetrate and colonize the media (Gasmi et al., 2021).

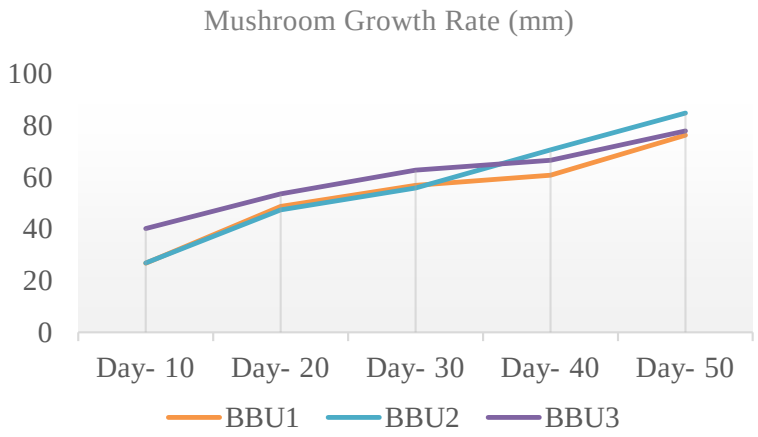
Effect of Environmental Conditions on Growth

Kumar & Kumar, (2017) reported that the optimal temperature for mycelial proliferation of *B.bassiana* is 25°C, with a decrease in growth rate at temperatures above 35°C. Research by Dhar et al., (2016) confirmed that the optimal incubation period of 7 days resulted in maximum radial growth, with isolate BbR2 reaching a diameter of 2.78 cm. The pH of the medium between 6-7 provided optimal conditions for maximum growth of all *B. bassiana* strains. Relative humidity of 60-75% in a temperature range of 24-28°C resulted in the fastest growth rate (Zhan et al., 2021). Research by Mascarin et al., (2021) reported that hyperosmotic conditions with high glucose concentrations (16-20%) can induce upregulation of antioxidant genes, calcium transport, and Osmo sensor-related genes, which contribute to more robust adaptation and growth. The variability in growth rates among *B.bassiana* BBU1, BBU2, and BBU3 isolates is a manifestation of intraspecific genetic diversity that affects metabolic efficiency, environmental adaptation, and potential application as biocontrol agents, providing a scientific basis for the selection and optimization of isolates in sustainable biological control programs. Gusti Yanda Prayoga et al., (2023) reported that biocontrol agents can increase the growth of cocoa seedlings. Endophytic bacterial isolates have been shown to be able to produce auxin, and microencapsulation applications provide the best growth results in plant height and leaf number parameters.

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Chart 1. Growth Rate Graph of *B.bassiana* Fungal Colony in Millimetres (mm)



BBU1- B.bassiana Repeat 1, BBU2- B.bassiana Repeat 2, BBU3- B.bassiana Repeat 3

Pest Mortality

The test was conducted by means of a suspension of *B.bassiana* which had been homogenized 10 -1 Which was applied by spraying using a hands prayer. Observations were made every day to see signs of pathogen infection, namely insects becoming sick by showing symptoms of not moving actively. The percentage of pest mortality was calculated using the formula:

$$P = \frac{A}{B} \times 100\%$$

Information:
P= Pest Mortality Percentage
A= Number of Dead Pests
B= Number of Pests Observed

Table 2. Mortality Percentage of Coffee Berry Borer Pest (*Hypothenemus hampei* F.) in Percent (%)

	Day						
	1	2	3	4	5	6	7
P0	0%	0%	0%	0%	0%	0%	0%
P1	0%	3%	10%	13%	17%	37%	40%
P2	17%	23%	33%	40%	53%	73%	97%
P3	23%	37%	57%	70%	87%	97%	100%
P4	20%	33%	40%	40%	53%	93%	100%

P0-control, P1-Egg Phase, P2-Larva Phase, P3-Pupa Phase, P4-Imago/adult Phase

Based on mortality observation data for 7 days, treatment P3 (pupa phase) showed the highest effectiveness with 100% mortality on the 7th day and the fastest LT_{50} (~2.6 days). In contrast, treatment P1 (egg phase) showed the lowest effectiveness with only 40% mortality on the 7th day and did not reach LT_{50} during the observation period. Treatments P2 (larvae) and P4 (imago) also achieved 100% mortality, but with a slower LT_{50} (~4.8 days). The high susceptibility of the pupal phase to *B.bassiana* fungal infection can be explained by several biological mechanisms. In the pupal phase, insects undergo a metamorphosis process involving reorganization of the immune system and changes in the cuticle structure and in a study by Sutanto et al., (2021) showed that

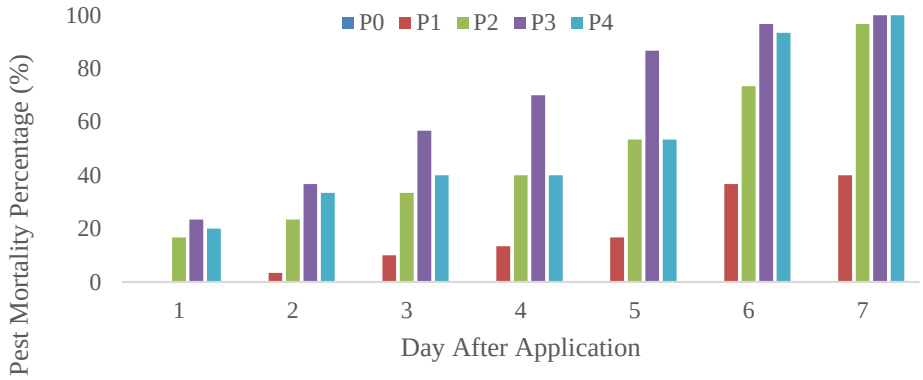
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E-ISSN: 2829-2421
https://doi.org/10.47709/joa.v4i02.6542

Rhynchophorus ferrugineus pupae had a mortality of up to 80% when exposed to *B.bassiana*, higher than the larval phase which only reached 73.3%. Furthermore, Weerasinghe & Traven, (2020) reported that high metabolic activity during metamorphosis also contributes to the vulnerability of pupae. The process of forming adult body structures requires large amounts of energy, so that the defence system against pathogens is limited. This condition allows entomopathogenic fungi to penetrate the cuticle more effectively and spread hyphae throughout the host body (Ferreira et al., 2023).

The low mortality in the egg phase (P1) is due to the structural and physiological characteristics of the egg shell (chorion) which acts as a physical barrier against fungal penetration. Ramayanti et al., (2023) reported that Aedes albopictus eggs have a chorion structure that is resistant to *M.anisopliae*, although they still show some susceptibility to *B.bassiana*. The effectiveness of *B.bassiana* against various stages of insect development has been consistently reported in the literature. Ferreira et al., (2023) evaluated 26 isolates of entomopathogenic fungi and found that isolate NCTB 04 (*Beauveria* sp.) achieved mortality above 85% against adult *H.hampei*. Bayman et al., (2021) reported that isolate *B.bassiana* Bb-NCHU-271 showed superior virulence against coffee berry borer in Taiwan. A comparative study by Chuquibala-Checan et al., (2023) confirmed the stage-specific mortality pattern, with *B.bassiana* concentration of 1×10^9 conidia/mL producing the highest mortality. The consistency of these results with research data indicates the validity of the findings regarding differential susceptibility between developmental stages. Laboratory evaluation of Bengkulu isolates by local researchers showed mortality of 76.7-80.0% for *B.bassiana* and 60.3-60% for *M.anisopliae* to coffee berry borer (Apriyanto & Nadrawati, 2019). Warsito et al., (2024) showed that endophytic bacterial filtrate was able to significantly inhibit the growth of upas fungus colonies.

Chart 2. Graph of Mortality Percentage of Coffee Berry Borer Pest (*Hypothenemus hampei* F)



P0-control, P1-Egg Phase, P2-Larva Phase, P3-Pupa Phase, P4-Imago/adult Phase

Differential susceptibility between developmental stages of *H.hampei* to *B.bassiana* is a consistent phenomenon and can be explained mechanistically, providing a scientific basis for the development of more effective and sustainable biological control strategies according to research by Yaninta Ginting et al., (2024) who reported that Development and effectiveness testing of plant bioinsecticides made from mahogany leaf extract as biological control agents to control armyworm pests on shallots. The results of the study showed that the use of plant bioinsecticides can significantly suppress pest populations and is an environmentally friendly alternative to conventional chemical pesticides. Furthermore, Warsito et al., (2024) reported that biological agents significantly increased the growth of coffee plants, both in terms of plant height, number of leaves, and leaf area. Endophytes act as innovative biofertilizers that support plant growth in

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an environmentally friendly manner.

Conclusion

The conclusion of the study on the Utilization of *Beauveria bassiana* Bals.-Criv Fungus to Control Coffee Berry Borer Pests (*Hypothenemus hampei* F.) In-vitro is that *Beauveria bassiana* Bals.-Criv. Fungus has the ability to control Coffee Berry Borer Pests (*Hypothenemus hampei* F.) Which shows the highest effectiveness in Treatment P3 (pupa phase) with 100% mortality on the 7th day and the fastest LT_{50} (~2.6 days). In contrast, treatment P1 (egg phase) showed the lowest effectiveness with only 40% mortality on the 7th day and did not reach LT_{50} in the observation period.

This research also provides significant benefits to science by offering new insights into the differential susceptibility of insect pest life stages to entomopathogenic fungi. It advances our understanding of host-pathogen interactions during insect metamorphosis, and contributes to the scientific basis for developing more targeted and effective biological control strategies in integrated pest management. Furthermore, these findings can inform future research into the optimization of biological agents for pest control in other economically important crops.

References

Affandi, A., Chailani, S. R., Mimbar, S. M., & Wiroatmodjo, B. (2012). ISOLATION AND PHENOTYPIC CHARACTERISATION OF MORPHOLOGY IN FUNGUS Beauveria bassiana (Balsamo) Vuillemin COLONY NATURALLY FROM LEAF SURFACE, SOIL, AND INSECT AS HOST IN TOMATO PLANTATION. *AGRIVITA Journal of Agricultural Science*, *34*(3). https://doi.org/10.17503/agrivita-2012-34-3-p303-310

Apriyanto, D., & Nadrawati. (2019). LABORATORY EVALUATION OF BENGKULU ISOLATES OF Beauveria bassiana AND Metarhizium anisopliae AGAINST COFFEE BERRY BORER, Hyphotenemus hampei, USING SPRAYING METHOD. *Journal of Tropical Plant Pests and Diseases*, *19*(2), 93–100. https://doi.org/10.23960/j.hptt.21993-100

Badan pusat statistik. (2020). statistik-kopi-indonesia-2020. *Badan Pusat Statistik*, *2714–8505*.https://www.bps.go.id/publication/2021/11/30/b1b6cf2a6aad1ee2d8a4c656/statistik-kopi-indonesia-2020.html

Badan Pusat Statistik. (2024). BADAN PUSAT STATISTIK BPS-STATISTICS INDONESIA. *Badan Pusat Statistik*, *8*(2714–8505). https://www.bps.go.id/en/publication/2024/11/29/d748d9bf594118fe112fc51e/indonesian-coffee-statistics-2023.html

Batta, Y. A. (2018). Efficacy of two species of entomopathogenic fungi against the stored-grain pest, sitophilus granarius l. (curculionidae: Coleoptera), via oral ingestion. *Egyptian Journal of Biological Pest Control*, *28*(1), 1–8. https://doi.org/10.1186/s41938-018-0048-x

Bayman, P., Mariño, Y. A., García-Rodríguez, N. M., Oduardo-Sierra, O. F., & Rehner, S. A. (2021). *Local isolates of Beauveria bassiana for control of the coffee berry borer Hypothenemus hampei in Puerto Rico: virulence, efficacy and persistence*.

Bayu, M. S. Y. I., Prayogo, Y., & Indiati, S. W. (2021). Beauveria bassiana: Biopestisida Ramah Lingkungan dan Efektif untuk Mengendalikan Hama dan Penyakit Tanaman. *Buletin Palawija*, *19*(1), 41. https://doi.org/10.21082/bulpa.v19n1.2021.p41-63

Chuquibala-Checan, B., Torres-De La Cruz, M., Leiva, S., Hernandez-Diaz, E., Rubio, K., Goñas, M., Arce-Inga, M., & Oliva-Cruz, M. (2023). In Vitro Biological Activity of

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Beauveria bassiana, Beauveria peruviensis, and Metarhizium sp. against Hypothenemus hampei (Coleoptera: Curculionidae). *International Journal of Agronomy*, *2023*. https://doi.org/10.1155/2023/4982399

Dhar, S., Jindal, V., & Gupta, V. K. (2016). Optimization of growth conditions and medium composition for improved conidiation of newly isolated Beauveria bassiana strains. In *Indian Journal of Experimental Biology* (Vol. 54).

Erfandari, O., & Supriyatdi, D. (2019). Keragaman Intensitas Serangan Hama Penggerek Buah Kopi (Hypothenemus hampei ferrari) Pada Beberapa Sentra Produksi Kopi Robusta di Provinsi Lampung Diversity of Intensity of Pest Attack Coffee Borrer (Hypothenemus hampei ferrari) on Some of Robusta Coffee Production Center in Lampung Province. *Jurnal Penelitian Pertanian Terapan*, *19*(3), 244–249. https://doi.org/10.25181/jppt.v19i3.298

Ferreira, J. S., Andaló, V., Marcelo, C., & Soares, S. (2023). Effect of entomopathogenic fungi on the control of the coffee berry borer in the laboratory. *Arq. Inst. Biol*, *90*, 2023. https://doi.org/10.1590/1808-1657000112023

Francisco Infante. (2018). Pest management strategies against the coffee berry borer (Coleoptera: Curculionidae: Scolytinae). *Journal of Agricultural and Food Chemistry*, *66*(21), 5275–5280. https://doi.org/https://doi.org/10.1021/acs.jafc.7b04875

Gasmi, L., Baek, S., Kim, J. C., Kim, S., Lee, M. R., Park, S. E., Shin, T. Y., Lee, S. J., Parker, B. L., & Kim, J. S. (2021). Gene diversity explains variation in biological features of insect killing fungus, Beauveria bassiana. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-020-78910-1

Gunawan, J. F., Afrianti, S., Pratomo, B., Agroteknologi, P. S., Agro, F., & Unpri Medan, T. (2024). Pengaruh Metharizium anisopliae(Metchnikoff) Sorokin dan Beauveria bassiana (Bals.-Criv.) Vuill terhadap Pertumbuhan dan Daya Tahan Hama Penyakit pada Bibit Kelapa Sawit (Pre nursery). *AGROPRIMATECH*, *8*(2), 2599–3232.

Gusti Yanda Prayoga, Kabul Warsito, & Hanifah Mutia Z.N. Amrul. (2023). Invasion Of Endophytic Bacteria By Using Microencapsulation Technology As Stimulant in Cocoa Plants (Theobroma cacao L). *JURNAL PEMBELAJARAN DAN BIOLOGI NUKLEUS*, *9*(1), 1–9. https://doi.org/10.36987/jpbn.v9i1.3815

Hollingsworth, R. G., Aristizábal, L. F., Shriner, S., Mascarin, G. M., Moral, R. de A., & Arthurs, S. P. (2020). Incorporating Beauveria bassiana Into an Integrated Pest Management Plan for Coffee Berry Borer in Hawaii. *Frontiers in Sustainable Food Systems*, *4*. https://doi.org/10.3389/fsufs.2020.00022

Johnson, M. A., Ruiz-Diaz, C. P., Manoukis, N. C., & Rodrigues, J. C. V. (2020). Coffee berry borer (Hypothenemus hampei), a global pest of coffee: Perspectives from historical and recent invasions, and future priorities. *Insects*, *11*(12), 1–35. https://doi.org/10.3390/insects11120882

Kumar, R., & Kumar, A. (2017). Growth rate in media and pathogenicity of two species of entomopathogens found in Fiji. In *Journal of South Pacific Agriculture* (Vol. 20).

Lee, D., Johnson, M. A., Aristizábal, L. F., Shriner, S., Chan, C., Miyasaka, S., & Wall, M. (2023). Economic Benefits from Managing Coffee Berry Borer (Hypothenemus hampei) in Hawaii. *Insects*, *14*(4). https://doi.org/10.3390/insects14040350

MARIA RANI RAKA SIWI. (2022). *UJI PATOGENISITAS BERBAGAI KONSENTRASI*

This is a Creative Commons License This work is licensed under a Creative Commons Attribution-Non-commercial 4.0 International License

Beauveria bassiana YANG DITUMBUH KAN PADA MEDIA LIMBAH ORGANIK SEBAGAI AGENS PENGENDALI HAYATI HAMA PENGGEREK BUAH KOPI (Hypothenemus hampei). universitas pembangunan nasional veteran.

Marleni, N., Gede, I., Titik, S. &, Aeny, N., Agroteknologi, J., Pertanian, F., Lampung, U., Brodjonegoro, J. S., & Lampung, B. (2013). EFIKASI Beauveria bassiana PADA PENGGEREK BUAH KOPI (Hypothenemus hampei) DARI SUMBERJAYA. In *Jurnal Agrotek Tropika* (Vol. 1, Issue 3).

Mascarin, G. M., Iwanicki, N. S., Ramirez, J. L., Delalibera, Í., & Dunlap, C. A. (2021). Transcriptional Responses of Beauveria bassiana Blastospores Cultured Under Varying Glucose Concentrations. *Frontiers in Cellular and Infection Microbiology*, *11*. https://doi.org/10.3389/fcimb.2021.644372

Nurul Dyah Parasmita, Dyah Nuning Erawati, & Ramadhan Taufika. (2024). AGROPROSS National Conference Proceedings of Agriculture Potensi Produksi Massal Beauveria bassiana Isolat Lokal Jember pada Media Dextrose Agar Potential for Mass Production of Local Jember Isolate of Beauveria bassiana on Dextrose Agar Media. *AGROPROSS*.

Octavia, A., Wantini, S., Studi IV Analis Kesehatan Politeknik Kesehatan Tanjungkarang, P. D., & Analis Kesehatan Politeknik Kesehatan Tanjungkarang, J. (2017). Perbandingan Pertumbuhan Jamur Aspergillus flavus Pada Media PDA (Potato Dextrose Agar) dan Media Alternatif dari Singkong (Manihot esculenta Crantz) Comparison of Aspergillus flavus Fungus Growth In PDA Media (Potato Dextrose Agar) and Alternative Media from Cassava (Manihot esculenta Crantz). In *Jurnal Analis Kesehatan* (Vol. 6, Issue 2).

Octavia Kita Sipayung, Y., Asi Nion, Y., & Adrianson Agus Djaya. (2023). Potensi Penambahan Bahan Organik Terhadap Sporulasi dan Infektivitas Beauveria Bassiana Pada Larva Oryctes Rhinoceros. *Jurnal Penelitian UPR*, *3*(2), 63–73.

Proietti, S., Falconieri, G. S., Bertini, L., Pascale, A., Bizzarri, E., Morales-Sanfrutos, J., Sabidó, E., Ruocco, M., Monti, M. M., Russo, A., Dziurka, K., Ceci, M., Loreto, F., & Caruso, C. (2023). Beauveria bassiana rewires molecular mechanisms related to growth and defense in tomato. *Journal of Experimental Botany*, *74*(14), 4225–4243. https://doi.org/10.1093/jxb/erad148

Rahardjo P. (2012). *Guide to the cultivation and processing of Arabica and Robusta coffee*. Penebar Swadaya.

Ramayanti, I., Herlinda, S., Muslim, A., Hasyim, H., Anwar, C., Suwandi, S., Damiri, N., Irsan, C., & Verawaty, M. (2023). Pathogenicity of entomopathogenic fungi to eggs, larvae, and adults and their effects on development of Aedes albopictus. *Biodiversitas*, *24*(9), 4766–4774. https://doi.org/10.13057/biodiv/d240917

Romón, P., Hatting, H., Goldarazena, A., & Iturrondobeitia, J. C. (2017). Variation in virulence of Beauveria bassiana and B. pseudobassiana to the pine weevil Pissodes nemorensis in relation to mycelium characteristics and virulence genes. *Fungal Biology*, *121*(2), 189–197. https://doi.org/10.1016/j.funbio.2016.11.008

Silviani, Alam Anshary, & Irwan Lakani. (2023). EFEKTIVITAS BEBERAPAJAMUR (Aspergillus sp,Beauveria Bassiana, Verticilliumsp)UNTUK MENGENDALIKAN PUPAPENGGEREK BUAH KAKAO (Conopomorpha cramerella Snellen). *Agrotekbis*. https://doi.org/https://doi.org/10.22487/agrotekbis.v...

Sutanto, K. D., Husain, M., Rasool, K. G., Al-Qahtani, W. H., & Aldawood, A. S. (2021).

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Pathogenicity of local and exotic entomopathogenic fungi isolates against different life stages of red palm weevil (Rhynchophorus ferrugineus). In *PLoS ONE* (Vol. 16, Issue 7 July). Public Library of Science. https://doi.org/10.1371/journal.pone.0255029

Syakir, M., & Surmaini, E. (2017). PERUBAHAN IKLIM DALAM KONTEKS SISTEM PRODUKSI DAN PENGEMBANGAN KOPI DI INDONESIA / Climate Change in the Contex of Production System and Coffee Development in Indonesia. *Jurnal Penelitian Dan Pengembangan Pertanian*, *36*(2), 77. https://doi.org/10.21082/jp3.v36n2.2017.p77-90

Utami, R. S., Ambarwati, R., Biologi, J., Matematika, F., Pengetahuan, I., Universitas, A., & Surabaya, N. (2014). Eksplorasi dan Karakterisasi Cendawan Entomopatogen Beauveria bassiana dari Kabupaten Malang dan Magetan Exploration and Characterization of Entomopathogenic Fungi Beauveria bassiana from Malang and Magetan Regency. *Lentera Bio*. http://ejournal.unesa.ac.id/index.php/lenterabio

Wahyudi, E., Martini, R., & Suswatiningsih, T. E. (2018). PERKEMBANGAN PERKEBUNAN KOPI DI INDONESIA. *Jurnal Masepi*, *3*(1).

Warlinson Girsang, Rosmadelina Purba, & Rudiyantono. (2020). THE INTENSITY OF PEST ATTACK COFFEE BORER (Hypothenemus hampei Ferr.) AT THE AGE LEVEL OF DIFFERENT COFFEE PLANTS AND CONTROL EFFORTS UTILIZE THE ATRAKTAN. *Journal TABARO*, *4*.

Warsito, K., Asmaq, N., & Irawan, I. (2024). Application of Microgranules from Endophyte Bacteria in Stimulating Vegetative Growth of Arabica Coffee (Coffea arabica L.). *International Journal of Research and Review*, *11*(11), 437–442. https://doi.org/10.52403/ijrr.20241141

Warsito, K., Asmaq, N., Irawan, I., & Taupik, M. (2024). Isolation and Antagonist Test of Arabica Coffee Endophyte Bacteria (Coffea Arabica L.) in Inhibiting Upas Fungus Growth (Corticium Salmonicolor B.Et. Br.). *International Conferance Of Digital Sciences And Engineering Technology* , *1*(1), 186–190. https://doi.org/https://proceeding.pancabudi.ac.id/index.php/ICDSET/article/view/179

Weerasinghe, H., & Traven, A. (2020). Immunometabolism in fungal infections: the need to eat to compete. In *Current Opinion in Microbiology* (Vol. 58, pp. 32–40). Elsevier Ltd. https://doi.org/10.1016/j.mib.2020.07.001

Yaninta Ginting, T., Warsito, K., & Sari Br Siregar, W. (2024). AGROPROSS National Conference Proceedings of Agriculture Evaluasi Efektivitas Bioinsektisida Nabati dari Ekstrak Daun Mahoni dan Sirsak Terhadap Mortalitas Ulat Grayak (Spodoptera exigua) Effectiveness Evaluation of Bioinsecticides from Mahogany and Soursop Leaf Extracts on Mortality (Spodoptera exigua). *Agropross, National Conference Proceedings of Agriculture*.

Zhan, Z., Xu, M., Li, Y., & Dong, M. (2021). The Relationship between Fungal Growth Rate and Temperature and Humidity. *International Journal of Engineering and Management Research*, *11*(3). https://doi.org/10.31033/ijemr.11.3.13

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