

Evaluating the Effects of *Beauveria bassiana* Against Fall Army Worm [*Spodoptera* *Frugiperda* (J.E. Smith)]

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Abstract

Corn (*Zea mays* L.) is an important crop in the Philippines, but an insect, the fall army worm (FAW) with scientific name *Spodoptera frugiperda*, threatens its productivity, causing a significant yield loss since it started invading corn crop in the country. They can be controlled with chemical pesticides, but they can pose risks to human health, non-target organisms, and the environment. This underscores the need to seed safer control alternatives like the entomopathogenic fungi (EPF). The study evaluated the effect of *Beauveria bassiana* at different conidial concentration levels of 1×10^7 , 1×10^8 , and 1×10^9 against the FAW larva at the third instar on potted corn plants at Northern Mindanao Agricultural Crops and Livestock Research Complex. The experimental area was laid out in a Randomized Complete Block Design (RCBD) with three replicates. The study aims to determine the effective concentration of EPF that can control fall army worm and assess the damage caused by fall army worm inoculated with EPF to the corn plants. The results revealed that *Beauveria bassiana* at 1×10^9 conidia/mL obtained the highest mortality and reduced the feeding damage incurred to the corn plant. To further assess the result of the experiment, a multi-location trial is recommended.

Keywords: *Beauveria bassiana*, conidial concentration, entomopathogenic fungi, feeding damage, mortality

1. INTRODUCTION

Corn (*Zea mays* L.) production in the Philippines is threatened by various insect pests. One of these is the fall army worm (*Spodoptera frugiperda*). It is an important agricultural pest that originates from America, and it was first detected in the Philippines in 2019. It has then spread to the entire country (Montecalvo et al., 2020) because it has a wide host range.

A control strategy is essential to protect its impact on food security, according to De Groote et al. (2020). It feeds on almost all the corn plant parts, and if left uncontrolled, it is estimated that it can cause damage up to 50% yield loss in corn (Bateman et al., 2021).

The use of biocontrol agents (BCA) is popularly known as an alternative to chemical pesticides in the control of insect pests. As they are considered natural remedies or enemies to numerous pests with no harmful effect on other beneficial insects, humans, and the environment. Among the biocontrol agents, entomopathogenic fungi (EPF) is considered as an option because it has high pathogenicity with a broad

host range (Khan et al., 2012). This includes *Beauveria bassiana*, which is known to infect hundreds of host insect species. It has high efficacy against insect pests, but it is non-pathogenic towards non-target pests (Dhawan & Joshi 2017).

The challenge in food production is to at least decrease insect pest infestation while protecting human health, beneficial insects, non-target organisms, and the environment. Hence, bio-pesticides are recommended as safer alternatives, minimizing adverse effects while effectively managing pest populations.

Objectives

The study aims to:

1. determine the most effective concentration of *Beauveria bassiana* that can control fall army worm, and
2. assess the severity of damage caused by fall army worm inoculated with EPF in corn crops.

2. REVIEW OF RELATED LITERATURE

Corn, *Zea mays*, is a staple cereal grain grown worldwide and serves as food for humans and livestock (Ranum et al., 2014). In the Philippines, corn, which is second to rice in importance, with about one third of the population relying on it for income (Gerpacio et al., 2004).

The fall army worm (FAW) completes its life cycle in approximately 30 days: eggs hatch at 2-3 days, the larval stage lasts about 14 days, while the pupa is up to 8-13 days in soil at 2 to 8 cm depth, and adults complete their cycle in 10-13 days (Tura et al., 2025).

Entomopathogenic fungi (EPF) are versatile and environmentally sound biological control agents for FAW, offering an effective alternative to chemical pesticides (Kidanu & Hagos, 2020). EPF differ in mode of action and virulence, but several species show promising effects against lepidopteran pests. *Beauveria bassiana*, in particular, has demonstrated high virulence and increased mortality against fall army worm in multiple studies (Wraight et al., 2010).

3. MATERIALS AND METHODS

The study was conducted at Department of Agriculture - RFO 10, Northern Mindanao Agricultural Crops and Livestock Research Complex (DA-RFO 10, NMACLRC) in Dalwangan, Malaybalay City, Bukidnon from May to July 2025.

3.1. Materials

A seven-day-old pure culture of *Beauveria bassiana*, potted corn, and nets were used in the study. The materials included were a hemocytometer for spore counting, sterilized distilled water, beakers, and a hand sprayer. A rearing jar and cut corn leaves were used as the diet of the larvae up to its desired instar. Ethyl alcohol, sterilized petri plates were used for collecting dead larvae. Also, markers, a record book for the data, a camera for proper documentation, and a laptop for data consolidation and interpretation.

3.2. Methods

3.2.1 Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. A control set-up served as the basis for comparison with treatments. Each treatment was consisting of five potted corn plants with only one larva to prevent cannibalism.

The treatments were the following:

Treatment 1: *Beauveria bassiana*+ 1x10⁷ conidia/mL

Treatment 2: *Beauveria bassiana*+ 1x10⁸ conidia/mL

Treatment 3: *Beauveria bassiana*+ 1x10⁹ conidia/mL

Treatment 4: Control (Water only)

3.2.2. Collection and Rearing of FAW

Collected clusters of egg masses of FAW from the corn fields for rearing to ensure uniform larval age. Upon hatching, the larvae were fed with cut corn leaves in 3x4 inches size and sterilized with distilled water and hypochlorite. It was transferred to a 3.5 mL rearing jar with a fine net for proper ventilation and food, so as not to compromise its health. They were reared individually to prevent cannibalism and were maintained at room temperature.

3.2.3. Preparation of Experimental Set-up

An open-pollinated variety (OPV) of corn was used in the experiment. Plants were grown individually in polyethylene pots with a size of 5 x 10 cm. All the potted plants received equal sun exposure and were enclosed with a fine net, which serves as blockage from other insect pests. A single third-instar FAW larva was introduced to each corn plant at the V4 growth stage and placed on the leaves or in the whorl. Each corn had one larva placed on the leaves or whorl of the corn. After all larvae had settled, assigned treatment solutions were sprayed onto each plant using a hand sprayer.

3.2.4. Preparation of the Entomopathogenic Fungi Suspension and Application

The *Beauveria bassiana* was cultured in an oatmeal agar medium to obtain a pure culture. The conidia of each *B. bassiana* were dislodged from the surface of sporulated cultures with a sterile spatula and were suspended separately in sterile distilled water. Three different spore solution concentrations of *B. bassiana* were measured using a hemocytometer: the low concentration is 1x10⁷ conidia/mL, the medium concentration is 1x10⁸ conidia/mL, and the high concentration is 1x10⁹ conidia/mL. The treatment concentration was applied late in the afternoon, between 4:00 pm and 6:00 pm. The control plants were sprayed with distilled water only. EPF were sprayed again after 7 days from the first application.

3.2.5. Biosafety Protocol in Disposal of Test Insect

Upon termination of the experimental setup, all live FAW larvae were discarded. These were collected and put in a sealed container to prevent escape and were brought to the laboratory and autoclaved for proper disposal.

3.3. Data Gathered

3.3.1. Percent Mortality/Treatment (daily)

Each experimental unit was observed daily. The exact time from treatment to mortality was recorded. To compute the mortality, the following formula was used:

$$\text{Percent Mortality} = \frac{\text{Number of dead larvae}}{\text{Total number of larvae introduced}} \times 100$$

3.3.2. Percent Corn Damage

Visual inspection of the corn leaves daily, using the visual leaf damage scale provided below. This measured the extent of injury or harm caused by FAW to the corn leaves. Using the leaf damage score by Davis and Williams 1992.

To compute the damage, the formula from Supartha, I. W. et al (2021) was used:

$$\text{Percent Severity Damage} = \frac{\sum (n \times v)}{N \times Z} \times 100$$

Where:

Z = Highest score (score) (9)

N = number of plants observed

n = number of plants that have a “v” value (crop damage)

v = the value (score) of crop damage based on the Davis and Williams 1992 leaf damage score.

Table 1. Level of leaf damage, score, and description in evaluating FAW feeding damage in corn

DAMAGE	SCORE	LEAF DAMAGE DESCRIPTION (Modified from Davis and Williams, 1992)
Low	1	No visible leaf feeding damage
	2	Few pinholes on 1-2 older leaves
	3	Several short-hole injuries on a few leaves (<5 leaves) and small circular hole damage on leaves
Medium	4	Several short-hole injuries on a several leaves (6-8 leaves) or small lesions/pin holes, small circular lesions and a few small elongated (rectangular- shaped lesions of up to 1.3 cm in length present on whorl and
	5	Elongated lesions (>2.5 cm long) on 8-10 leaves, plus a few small- to mid-sized uniform to irregular- shaped holes (basement membrane consumed eaten from the whorl and/or furl leaves
	6	Several large elongated lesions present on several whorl and furl leaves and /or several large uniform to irregular-shaped holes eaten from the whorl and
	7	Many elongated lesions of all sizes present on several whorl and furl leaves plus several large uniform to irregular- shaped holes eaten from the whorl
High	8	Many elongated lesions of all sizes present on most whorl and furl leaves plus many mid-to large sized uniform to irregular- shaped holes eaten at
	9	Whorl and furl leaves almost totally destroyed and plant dying as a result of extensive foliar damage

3.3.3. Statistical Analysis

The data was tabulated and analyzed using the analysis of variance (ANOVA). The Tukey's Honest Significance Difference (HSD) Test was used to identify specific differences between treatment means.

4. RESULTS AND DISCUSSIONS

The mortality of fall army worm from seven days after inoculation at different concentration levels of *Beauveria bassiana* is shown in Table 2 and was highly significant, indicating that larval mortality varied according to the concentration applied. The control treatment, which received water only, recorded 0.00% mortality, confirming that no other factors affected larval death during the experiment. In contrast, all other treatments caused mortality at seven days after inoculation. Among the treatments, the highest concentration of 1×10^9 conidia/mL obtained the highest larval mortality at 53.33%, which was significantly higher than the lower concentrations. Meanwhile, concentrations 1×10^7 and 1×10^8 conidia/mL obtained 20.00% and 33.33% mortality, respectively, but were statistically similar. The increase in conidial attachment likely enhanced spore concentration on the insect cuticle and promoted penetration into the host body, leading to faster fungal colonization and death (Mascarin & Jaronski,

2016). Similar findings were reported by Akutse et al. (2020), that *B. bassiana* can cause higher mortality of *S. frugiperda* larva at higher concentrations.

Table 2. Mean mortality of fall army worm seven days after inoculation with different concentration levels of *Beauveria bassiana*

Treatment	Mortality (%)
<i>Beauveria bassiana</i> at 1×10^7 conidia/mL	20.00 ^b
<i>Beauveria bassiana</i> at 1×10^8 conidia/mL	33.33 ^b
<i>Beauveria bassiana</i> at 1×10^9 conidia/mL	53.33 ^a
Control (Water)	0.00 ^c
F-test	**
CV (%)	5.6

The data in Table 3 showed a significant difference among treatments, indicating that FAW inoculated with *Beauveria bassiana* significantly reduced the percentage of feeding damage caused by *S. frugiperda* on corn at seven days after inoculation (DAI). The control treatment, which is applied with water only, obtained the highest feeding damage at 45.93%. All the treatments inoculated with *B. bassiana* at different concentration levels minimized corn feeding damage, with feeding injury reduced to 36.30%, 34.81%, and 33.33% at concentrations of 1×10^7 , 1×10^8 , and 1×10^9 conidia/mL, respectively. These treatments were statistically similar. Although no significant differences were observed among different concentrations based on Tukey’s HSD test, a numerical trend was evident, with higher concentrations suppressing FAW feeding damage more effectively. This suggests that increased conidial concentration may enhance the ability of *B. bassiana* to infect FAW larvae and reduce feeding activity. Akutse et al. (2020) likewise reported that *B. bassiana* reduced both feeding damage and larval survival.

Table 3. Percentage of feeding damage caused by fall army worm in corn seven days after inoculation with *Beauveria bassiana*.

Treatment	Feeding Damage (%)
<i>Beauveria bassiana</i> at 1×10^7 conidia/mL	36.30 ^b
<i>Beauveria bassiana</i> at 1×10^8 conidia/mL	34.81 ^b
<i>Beauveria bassiana</i> at 1×10^9 conidia/mL	33.33 ^b
Control (Water)	45.93 ^a
F-test	**
CV (%)	4.73

The results showed that *Beauveria bassiana* + 1×10^9 conidia/mL obtained the highest mortality of 53.33% 7-days after inoculation, while the control treatment had 0.00% mortality. On the feeding damage data, control treatment obtained the most serious damage of 45.93% seven (7) days after inoculation, while the *B. bassiana* treatment had no significant differences with each other, but numerically, the *B. bassiana* + 1×10^9 conidia/mL obtained the lowest feeding damage, followed by *B. bassiana* + 1×10^8 conidia/mL and *B. bassiana* + 1×10^7 conidia/mL.

5. CONCLUSION AND RECOMMENDATIONS

Beauveria bassiana caused significant mortality of third-instar *Spodoptera frugiperda* and reduced leaf feeding damage on potted corn under the conditions of this study. Among the tested doses, the highest conidial concentration (1×10^9 conidia/mL) produced the greatest larval mortality at 7 DAI and the lowest mean feeding-damage score, while the water control showed no mortality with the most serious damage. These results indicate a clear dose–response trend: increasing conidial concentration increased infection success and suppressed feeding activity, determined as the most effective concentration. In assessing the severity of damage, treated plants suffered significantly less foliar injury than the control, showing that *B. bassiana* applications can meaningfully reduce short-term feeding damage on V4 corn under enclosed, pot-trial conditions. However, because the experiment was pot-based, carried out within fine netting and under uniform microclimate, extrapolation to field performance is limited; environmental factors (UV, temperature, humidity), natural enemies, and application logistics will influence efficacy in open-field conditions.

It is recommended that *Beauveria bassiana* at 1×10^9 conidia/mL be used as the most effective concentration for controlling fall army worm and reducing feeding damage on corn under conditions similar with the study. However, to strengthen the applicability of the findings, further studies should be conducted under field conditions and across multiple locations to verify their effectiveness in diverse environments. Future research should also evaluate its performance at different crop growth stages, application intervals, and formulation types, as well as its compatibility with other integrated pest management strategies. In addition, economic analysis and farmer participatory trials are recommended to determine its practicality, cost-effectiveness, and acceptability for wider adoption.

6. APPENDICES

Appendix Table 1. Analysis of variance on mean mortality of fall army worm seven days after inoculation with different concentration levels of *Beauveria bassiana*

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Replication	2	9.9013	4.9506	1.8ns	0.2439
Treatment	3	231.4314	77.1438	28.07**	0.0006
Error	6	16.4873	2.7479		
Total	11	257.8199			

CV (%) = 5.6 ** - significant ns - not significant

Appendix Table 2. Mean percentage of feeding damage caused by fall army worm in corn after inoculation with *Beauveria bassiana* at 7-days after inoculation

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Replication	2	0.4625	0.2313	0.44ns	0.6604
Treatment	3	71.4321	23.8107	45.81**	0.0002
Error	6	3.1188	0.5195		
Total	11	75.0134			

CV (%) = 4.73 ** - significant ns - not significant

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