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Article

The role of Entomopathogenic Fungi as Biological Control Agents Against Agricultural Insect Pests

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Abstract: Sophisticated biological control are vital, ecofriendly environmentally beneficial solutions. Using entomopathogenic fungi is vital and crucial biological control strategies. The current study is designed to use several fungal formulations including entomopathogenic fungi to control (ctrl) Spodoptera littoralis larvae in soybean crops. Bioassays of Spodoptera littoralis larvae treated with fungal entomopathogens showed mortality rates ranging from 86.60% for LPSc, 1098 to about 56.60% (Metarhizium anisopliae L.) for LPS, 907). Laboratory trials various formulation of (B. bassiana L.) were used, formulation 4 (LPS., 1084) exposure mortality percentage to hundred percent, and formulation 5. (LPS., 1098) with 97.0%. Under field conditions, larval mortality was 80% for formulation 4 and 60% for formulation F5. Field experiments with LPS., 1084 are required. Finally, investigation indicate that fungal formulation could be employed in the field to manage Spodoptera littoralis.

Keywords: Biological control, entomopathogenic fungi. Spodoptera littoralis and field conditions.

Introduction

Entomopathogenic fungi had recently been used in sustainable insect control efforts [1]. Compared to traditional pesticides, entomopathogenic fungi provide a number of benefits, such as low cost, productivity, there is un detrimental harm on useful creatures, reduced residues, plus enhanced ecosystem. A growing body of research has demonstrated substantial biocontrol potential entomopathogenic fungi, increasingly incorporated into novel integrated pest management (I.P.M.) strategies. Naturally occurring entomopathogens play a significant regulating role in insect populations [2]. There is an increasing interest in using fungal infections to treat insect pests. Entomopathogenic fungi are naturally occurring in agroecosystems and can suppress insect pests [3]. Spodoptera littoralis (Lepidoptera: Noctuidae) is a potential pest of cash crop like soybeans, alfalfa., cottons, phaseolus, & flax [4]. A number of insect pests attack this crop, resulting in significant economic losses. As a result, avoiding damage is a primary issue [5]. Spodoptera littoralis had numerous enemies naturally, including fungus. Conversely, farmers favor pesticide such as diamides, phosphorus, plus pyrethroids. Recent issues with harmful insecticides influence regarding populations of bees which noted [6]. The

entomopathogenic provide a viable approach to reduce crop losses caused by insect pests, solving sustainability concerns as reported [7].

Beauveria bassiana (*Hypocreales: Cordycipitaceae*) is an entomopathogenic fungus infects insects through their cuticles making it a common pest [8], [9]. Synthetic insecticides have been widely used against this pest; however, concerns over pesticide resistance and environmental harm have intensified the search for sustainable alternatives. Among the most promising options, can achieve effective biocontrol of this pest [10]. Optional saprophyte which is (*B. bassiana L.*) that can coexist with plants as endophytes [11], [12]. According to pesticides damage the environment and leave residues in food all around the world [13]. they suggest developing safer, innovative, and biodegradable biopesticides as insecticide alternatives [14]. The infection mechanism of B. bassiana involves several sequential steps: conidial adhesion to the insect cuticle, appressoria formation, penetration through the cuticle via enzymatic degradation (involving proteases, lipases, and chitinases), hyphal growth within the hemocoel, and ultimately host death followed by external conidiation [15]. This multi-step process underscores the importance of conidial viability and environmental stability in determining field efficacy, making formulation design a critical component of any mycoinsecticide development program [16]. So, the objective of the current study to apply on farm various formulations by used entomopathogenic to control Spodoptera littoralis in soybean plants.

Materials and Methods

Rearing Insect:

Spodoptera littoralis (Boised.) were grouped from (College of Agriculture, Tekret University, Salahddin Province., the Republic of Iraq.), where colonies had not been treated with insecticides for several generations. According to The larvae grown in 25 ± 2°C., 75.0 % R.H. Castor leaves were supplied as nourishment for the larvae. L3 phase used in pathogenicity tests [17].

The Fungal Colonies:

The fungal colonies selected at the Department of Plant Protection., College of Agriculture., Tekret University., Salahddin Province, the Republic of Iraq. The colonies employed were LPSc 1066., LPSc. 1084., LPSc. 1096., LPSc. 1158., LPSc. 1224., LPSc. 1226., LPSc. 1227. of Beauveria bassiana, LPSc. 908. of Metarhizium anisopliae, and LPSc. 964. of *M. rileyi.*. as well as colonies cultivated on agar-agar for 10 days (25°C.) darkness. Conidia were gathered using antiseptic scrapers., then deposited in the tubes which containing 0.01%. (v./v.) polyoxyethylene sorbitan monolaurate. (Tween 80.), vexed up to 120 seconds, and filtered through four layers of sterile muslin. 1×108., solutions of conidia ml^{-1} using a hemocytometer. According to the vitality of the conidia from each isolate utilized in the test was assessed after 24 hours with a suspension of 1.0×10^4, (conidia ml^{-1}) [18].

The pathogenicity assays:

Assess the assay of pathogenicity was used Spodoptera littoralis (Boised) mortality assessment, larvae L3., with aforementioned fungus. Sprayed larvae 300 µl individually each treatment using sprayer of 0.10 ± 0.02/ml. 30 cm^3 settled in container made of plastic with an artificial food ad libitum. Treatments had three times (on separate days) of ten people and a ctrl groups. Larvae in ctrl were infected with Tween 80. 0.01% (v./v.). The larvae were maintained at 25 ± 0.5°C. and 75% relative humidity in a temperature-controlled facility.

According to mortality recorded daily up to ten days; deceased individuals were surface-antiseptic which placed in humid room 25°C. in the dark to promote fungal development. By examining the dead larvae under a microscope, mycosis was verified. Statistix 8 software was used to assess significant differences in mortality percentages [19].

Liquid formulation development:

Creating a formulation of mycoinsecticide mixed substances is utilized to ensure entomopathogenic conidia remain stable, contagious, and easy apply.

Table 1. Five fungal formulations tested using various components.

Tested Formulated	Strain LPSC	Defoamer g/l.	Tween 80	H_2O	Oil in mineral	Glucose g/l	NaCl g/l.	Medium Lm/l	Medium Cz	Medium G	Yeast extract	Buffer	CaCO3
F1	1512	30	50	250	0.99	-	-	-	-	-	-	-	-
F2	1617	30	-	-	-	10	0.49	100	-	-	1.32	-	0.99
F3	1714	-	-	-	-	-	-	-	-	100	-	3.8	-
F4	1520	30	50	-	-	-	-	-	100	-	-	-	-
F5	1535	30	50	-	-	-	-	-	100	-	-	3.8	-

In the current study, five various formulations were designed using, the colonies that are most harmful to (*Spodoptera littoralis* L.) (LPSc. 1066., LPSc. 1084., LPSc. 1096., LPSc. 1158., LPSc. 1224., LPSc. 1226., LPSc 1227 of Beauveria bassiana, LPSc. 908. of Metarhizium anisopliae, and LPSc 964 of *M. rileyi*.). In bioreactors, conidia from each fungal colony were produced on large quantities. A defoamer (a polymer containing non-ionic emulsifiers) was used plus decrease, prevent foam formation. Tween 80 were used to minimize conidia agglutination. Liquid mineral oil was used as conidia carrier & protector. As a co-adjuvant, a mixture of methyl esters (natural oil, silicone & polymer) used to increase penetration and facilitate cuticular absorption, as well as to promote better drop spread and uniformity Rizospray. Extremo., Rizobacter. [20], [21]. Oil & water combination created by combining the surfactant phase with the aqueous suspension spore, beaker with a magnetic stirring rod, and swirling for sixty minutes on a Velp brand magnetic stirrer until a homogenous mixture achieved. Triton, a non-ionic surfactant, was also added at a 1% dosage. Developed colonies in erlenmeyer flasks then planted in mini-vats (ten liters), minicubes tuned to 29°C., 200 R.P.M., 0.5 L.P.M., & 1.5. V.V.M. Flasks, with defoamer was also linked to minicubes to overcome fungal strain's foam. For every composition, the colonies utilized in each combination were cultivated for six days. After the minicubes' growth was complete and their purity was examined under a microscope, they were placed in Pyrex bottles to be combined with other additives later. The formulation was changed to 1× 108 conidia/ml.

Laboratory test using fungal formulations:

Larval mortality was assessed using Spodoptera littoralis third instar larvae. Individual larvae were sprayed with each formulation (300 µl) using a glass sprayer (discharge rate 0.10 ± 0.020 ml.). The larvae were then placed in sterile containers (30.0 cm^3) and fed an artificial meal ad libitum. Each formulation was evaluated in three replicates (on different days) with ten participants and a ctrl.

The control larvae were sprayed in the same manner, but the fungal inoculum was not included; instead, just excipients from formulation present, as shown in **Table 1**. The larvae were placed in a climate chamber, and their cumulative mortality was monitored for ten days. The same method was used to confirm death from mycosis as in the pathogenicity test. Data were analyzed using Statistix 8 software, with an analysis of variance (A.N.O.VA.) to assess for significant variations in fatality percentages across treatments.

Field test

The two formulations that had the highest mortality rate on Spodoptera littoralis larvae in earlier laboratory research were used in the field study. The field was situated in the province of Salahddin at Tekret University. Three controls and two treatments were included in the trial. In Iraq, Spodoptera littoralis F4.-F5. ctrl (chemicals from each formulation) are frequently managed using Coragen 20% (DuPont. S.A.), a chemical positive control. Six randomly selected plots were allocated to each treatment.

Four 50-cm-long soybean furrows were made in each plot. Furrow was used to select the plants. Number of 20 L3 larvae applied to leaves of every plant using entomological tweezers and brushes so as not to harm the insects. Regarding to Randomized Block Design (R.C.B.D.) to less errors due to field soil heterogeneity. To keep larvae from escaping, the plants were wrapped in an anti-aphid net [22]. The mixtures were applied using a backpack and a carbon dioxide bottle. Integrum, an adjuvant consisting of 6 a surface molecule and a modified oil, was used in field applications. This substance was utilized to maximize compound penetration and reduce treatment evaporation. The formulation dose utilized was approximately 200.0 ml per hectare. Every plant visited every day for count mortality.

Insects were collected and placed inside vials, which were transported laboratory to ascertain mycosis-related death, mentioned in previous parts. changes in larval mortality across treatments (chemical-fungi) were examined using an analysis of variance (A.N.O.V.A.) with the program Statistix verg. 8.

Statistical Analysis

Prior to statistical analysis, all larval death and mortality adjusted for natural control mortality using Abbott's formula. A one-way analysis of variance (A.N.O.V.A.) was performed on corrected mortality percentages from pathogenicity assays, laboratory formulation testing, and field trials using Statistix verg. 8. software (Tallahassee software, U.S.A.). Tukey's Honestly Significant Differences, (H.S.D.) utilized to separate means at the same significance threshold when A.N.O.V.A. revealed significant treatment effects ($p \leq 0.05$.). Three replicates of each treatment were conducted on different days (n = 10 larvae per replicates; total n. = 30 per treatment). The data are presented as mean percentage mortality ± standard deviation (SD).

Results

1. Pathogenicity Assays

The virulence of the ten fungal colonies evaluated against Spodoptera littoralis third-instar (L3.) larvae varied depending on the treat. Among the isolates of B. bassiana, strain LPSc. 1098. had larval death about 86.60 ± 8.40%., whereas the mortality values of the other strains were in the middle.

The strain of M. anisopliae (LPSc. 907.) produced the lowest death rate (56.60 ± 5.10%.). There was no larval mortality at ctrl, indicating that fungal infection was the cause of the reported deaths.

Table 2 summarizes the mortality hierarchy for all isolates, and **Figure 1** shows the mean percent mortality for all colonies.

Table 2. Pathogenicity of fungal isolates against S. littoralis L3. larvae.

Fungal Species	Isolate (LPSc.).	Mean Mortality. ± SD. (%)
(Beauveria bassiana L.)	1098	86.6 ± 8.40
(Beauveria bassiana L.)	1084	82.3 ± 6.20*
(Beauveria bassiana L.)	1227	79.8 ± 7.10*
(Beauveria bassiana L.)	1226	76.5 ± 5.80*
(Beauveria bassiana L.)	1224	73.2 ± 6.50*
(Beauveria bassiana L.)	1158	70.4 ± 4.90*
(Beauveria bassiana L.)	1096	68.1 ± 5.30*
(Beauveria bassiana L.)	1066	64.7 ± 6.80*
(Metarhizium rileyi L.)	964	60.0 ± 4.50*
(Metarhizium anisopliae).	907	56.6 ± 5.10
Control (Tween 80 0.01%).	—	0.0 ± 0.00

*Intermediate values estimated from Figure 1; highest and lowest values are from reported data.

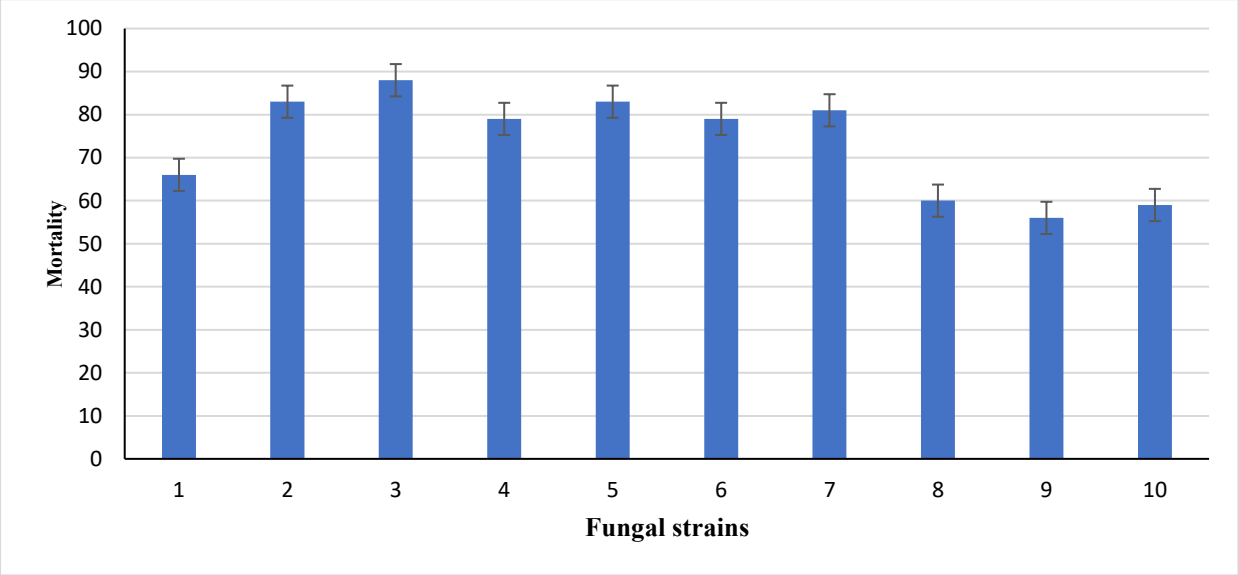

Figure 1. Mean percent mortality (± SD) of S. littoralis L3 larvae inoculated with 10 fungal isolates (LPSc 1066, 1084, 1096, 1098, 1158, 1224, 1226, 1227 of Beauveria bassiana; LPSc 907 of Metarhizium anisopliae; LPSc 964 of M. rileyi). Significant differences are indicated with letters $p < 0.05$.

2. Laboratory Tests with Fungal Formulations

Laboratory bioassays with the five fungal formulations revealed significant differences in larval mortality. Formulation F4, containing B. bassiana (LPSc 1084) in a Czapek-Dox medium with Tween 80 and defoamer, achieved the highest mortality rate (100%), establishing complete lethality against S. littoralis larvae within the 10-day observation period. Formulation F5, comprising B. bassiana (LPSc 1098) in Czapek-Dox medium with Tween 80, buffer, and defoamer, followed closely with 97% mortality. Formulation F1 produced the lowest mortality (83%), while no larval deaths were recorded in the excipient-only controls, confirming the role of fungal conidia as the causative agent of mortality. Results for all formulations are presented in Table 3 and illustrated in Figure 2.

Table 3. Mortality (%) of S. littoralis L3 larvae treated in a lab setting using five fungal preparations.

Formulations.	Fungal Strain (LPS.)	Key Components	Mortality (%)
F1	1512 (B. bassiana)	Defoamer, Tween 80, H_2O, Mineral oil	83.0
F2	1617 (B. bassiana)	Defoamer, Glucose, NaCl, Medium Lm, Yeast extract, $CaCO_3$	87.3*
F3	1714 (B. bassiana)	Medium G, Buffer	79.5*
F4	1520 (B. bassiana)	Defoamer, Tween 80, Medium Cz	100.0
F5	1535 (B. bassiana)	Defoamer, Tween 80, Medium Cz, Buffer	97.0

Control (F4 excipients, no conidia)	—	—	0.0
Control (F5 excipients, no conidia)	—	—	0.0

*Values estimated from Figure 2.

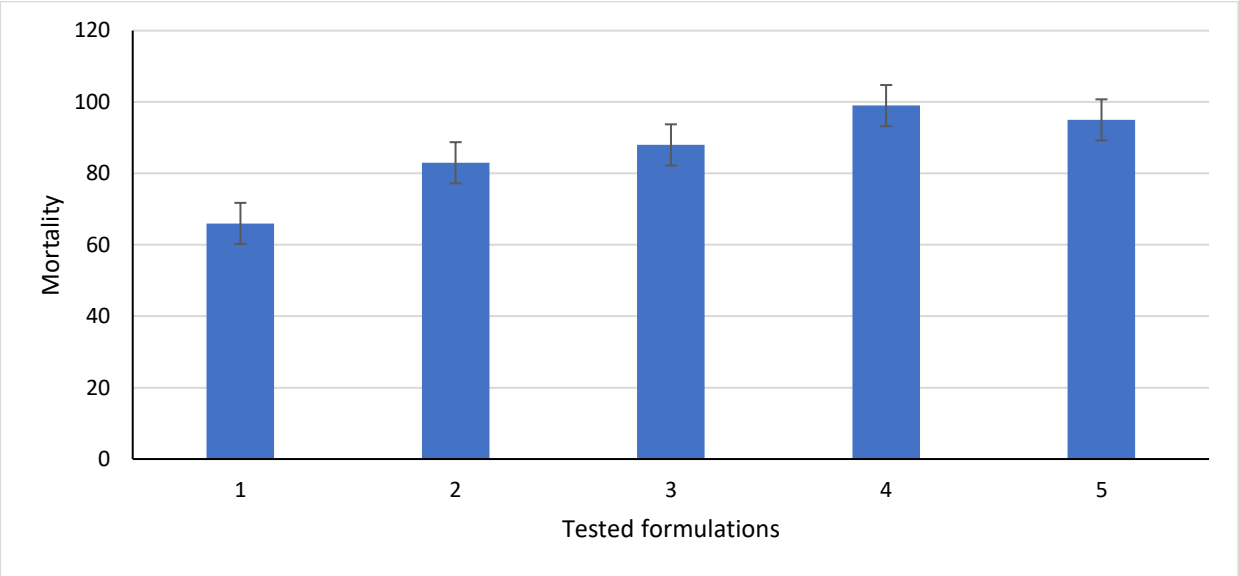

Figure 2. Mean percent mortality (± SD) of S. littoralis L3 larvae in laboratory bioassays inoculated with five B. bassiana fungal formulations (F1–F5) and respective controls. Values represent means of three replicates (n = 10 larvae per replicate).

3. Field Tests.

There were notable variations in larval mortality between the two fungal formulations and their corresponding controls in the field. Due to outdoor factors including UV light and temperature change, Formulation F4 showed the maximum fungal mortality (80.0%), indicating robust field performance despite a decline compared to laboratory circumstances. The maximum overall mortality (87.5%) was attained by the chemical standard (Coragen 20% SC), demonstrating its effectiveness as a positive control.

The mortality rate from Formulation F5 was 60.0%. Both of the untreated excipient controls' death rates (F4 control: 5%; F5 control: 10%) stayed significantly below 20%, indicating that the active fungal component was the cause of the observed mortality. Table 4 and Figure 3 display all of the field mortality statistics.

Table 4. Mortality (%) of S. littoralis L3 larvae under field conditions for fungal formulations F4 and F5, chemical standard (Coragen 20%), and excipient controls.

Treatment	Type.	Mortality (%)
Formulation F4 (B. bassiana LPSc 1084.).	Mycoinsecticide.	80.0
Formulation F5 (B. bassiana LPSc 1098.).	Mycoinsecticide.	60.0
Coragen 20% SC (Chlorantraniliprole.).	Chemical control (+).	87.5
F4 excipients only (no conidia.).	Negative control.	5.0
F5 excipients only (no conidia.).	Negative control.	10.0

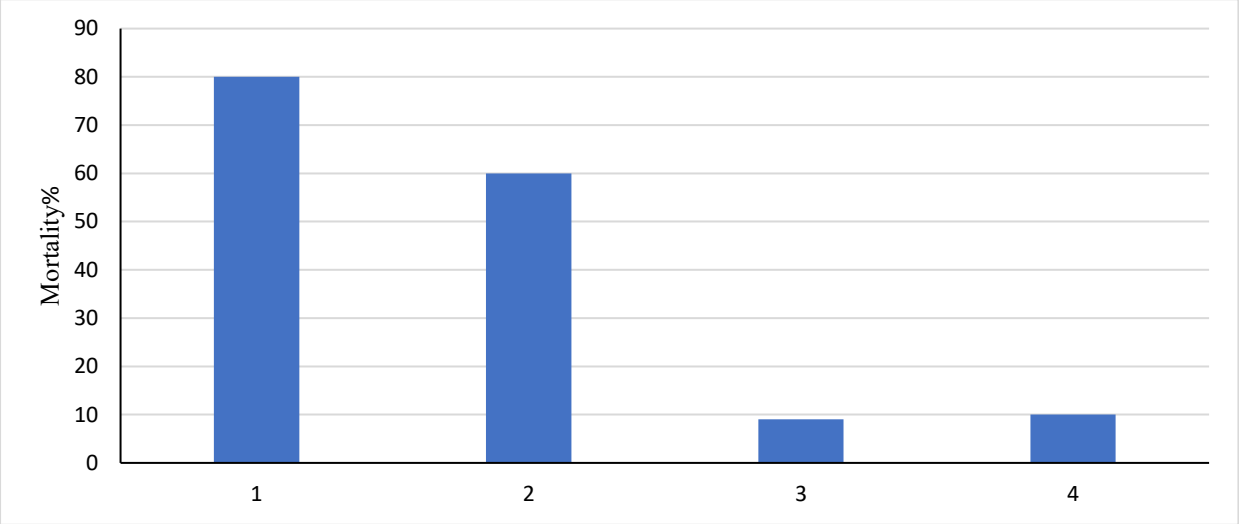

Figure 3. Mean percent mortality of S. littoralis L3. larvae under field conditions following application of formulations F4 and F5, chemical control (Coragen 20% SC.), and respective excipient controls (F4-ctrl., F5-ctrl.). Bars represent treatment means.

Discussions

In this study, third-instar S. littoralis larvae were used to test the entomopathogenic severity fungus Beauveria bassiana (Ascomycota, Hypocreales) controlled field & laboratory trials. When producing entomopathogenic fungi in large quantities, it is crucial to consider more than just the economic and technological feasibility, but therefore mode of action because the finished product must contain infectious structures and active metabolites, show stability, and have the highest biological potential [23]. The primary UV component that has the most potential to damage conidia and is responsible for the low field persistence of mycoinsecticides [24], [25]. In order to preserve fungal propagules from photodegradation and increase their field persistence, UV protectants are frequently included to mycoinsecticide bioformulations. To increase effectiveness, surface coverage, formulation adhesion, and penetration, surfactants and adjuvants are commonly used in foliar treatments. However, several studies have shown that some oil-depend surfactants may alter both entomopathogenic fungi severity and the survivability of conidia [26]. Similar outcomes were found with B. bassiana, who reported 50% mortality in Spodoptera frugiperda larvae [27]. Formulation 4 with the B. bassiana strain (LPSc 1084) exposure the highest mortality rate about hundred percent 100.0 % in the lab, formulation 5 comes next with the B. bassiana strain (LPSc. 1098.) (97%). Discovered that lepidoptera larvae (*Plutella xylostella* L.) had an average death rate of 77% [28]. Microbial agents are protected from sun damage by adjuvants and other materials, which prolongs their survival in the environment [29]. Formulations F4 and F5 of this investigation employed the commercial adjuvant Rizospray Extremo to shield conidia from environmental factors. The inconsistent results on the efficacy of bioformulations, especially in field settings, are one of the biggest barriers to their use. Claims that applying conidia to sugar beet plants in the field greatly decreased the number of Spodoptera [30]. In current study, mycoinsecticides efficacy assessed following a single application. The quantity of infectious conidia would rise with a second spray, which would enable the formulations achieve better biocontrol, according to certain research [31], [32]. Obtained outcomes show the tested formulations, especially F4, have a great deal of promise for field application in the management of Spodoptera littoralis, which would lessen the need for insecticides to pest control. Outcomes, of the current investigation indicate that the adjuvant combinations utilized in F4 and F5 were compatible with fungal vitality at effective levels, despite reporting that some surfactant combinations can limit conidia viability [26].

Conclusions and future prospects

The study's findings demonstrate the importance of entomopathogenic fungal endophytes in pest control tactics to increase agricultural productivity. It also demonstrated that the

entomopathogenic fungus could kill Spodoptera littoralis larvae at acceptable rates. Fungal conidia sprayed on field-grown soybean plants reduced the number of insect larvae. It has been proposed that using entomopathogenic fungus to manage Spodoptera littoralis larvae could lower the pest population and remove the environmental risks regarding to long-term pesticides used. Specifically, F4 formulation B. bassiana (LPSc. 1084.) shown excellent efficacy both in the field (80%) and in the lab (100%), making it a viable option for integration into IPM systems. Future research should concentrate on the following areas: (i) enhancing F4's UV-protective chemicals. formulations to improve field persistence; (ii) examining the effects of repeated applications on cumulative larval mortality; (iii) assessing the compatibility of these formulations with other IPM elements, like parasitoids; and (iv) looking into the possibility of these strains colonizing soybean plants endophytically for systematic protection. Understanding the relationships between fungal endophytes and plants is necessary to develop next-generation EPF-based biological control methods. The actual application of EPF in IPM systems also requires a thorough evaluation of the biotic and abiotic variables affecting endophytic behavior and insecticidal effectiveness. Due to the paucity of research in this area, thousands of endophytic EPF strains are thought to remain unexplored. Finding and evaluating these hitherto unreported EPF endophytic strains is crucial.

REFERENCES

[1] K. Minhans *et al.*, "Harnessing the Biopotential of Entomopathogenic Fungi for Integrated Pest Management," *Journal of Phytopathology*, vol. 174, no. 2, 2026.
[2] H. E. Roy and T. E. Cottrell, "Forgotten natural enemies: Interactions between coccinellids and insect-parasitic fungi," *European Journal of Entomology*, vol. 105, no. 3, pp. 391–398, 2008.
[3] B. Deka, C. Baruah, and A. Babu, "Entomopathogenic microorganisms: their role in insect pest management," *Egyptian Journal of Biological Pest Control*, vol. 31, no. 1, 2021.
[4] A. M. Mohammad and E. S. N. Abd El Mageed, "Characterization and Evaluation of Some Actinomycetes Isolates…," *Egyptian Academic Journal of Biological Sciences*, 2026.
[5] R. G. Attia *et al.*, "Synergistic activity of sunlight protectants…," *Scientific Reports*, 2026.
[6] A. Schuhmann *et al.*, "Interaction of insecticides and fungicides in bees," *Frontiers in Insect Science*, 2022.
[7] M. Ghorui, S. Chowdhury, and S. Burla, "The science behind entomopathogenic fungi…," CRC Press, 2025.
[8] W. Huang *et al.*, "Defense Against Beauveria bassiana Infection," *Frontiers in Immunology*, 2021.
[9] T. M. Butt, C. Jackson, and N. Magan, *Fungi as Biocontrol Agents*, CABI, 2001.
[10] U. M. Maina *et al.*, "Use of entomopathogenic fungi in pest management," *J. Entomol. Zool. Stud.*, 2018.
[11] L. A. Bing and L. C. Lewis, "Endophytic Beauveria bassiana in corn," *Biocontrol Sci. Technol.*, 1992.
[12] M. L. Russo *et al.*, "Endophytic colonisation…," *Biocontrol Science and Technology*, 2015.
[13] WHO, "Agrochemicals, health and environment," 2017.
[14] S. Chaudhary *et al.*, "Biopesticides in replacing synthetic pesticides," *Frontiers in Plant Science*, 2017.
[15] Z. Luo, Y. Qin, and Y. Pei, "MAPK in Beauveria bassiana infection," *Appl. Environ. Microbiol.*, 2010.
[16] R. Lohse, D. Jakobs-Schönwandt, and A. V. Patel, "Fermentation of Beauveria bassiana," *AMB Express*, 2014.
[17] C. Ivaldi-Sender, "Techniques for insect rearing," 1974.
[18] G. D. Inglis, D. L. Johnson, and M. S. Goettel, "Effect of formulation on infection," *Biocontrol Sci. Technol.*, 1996.
[19] R. A. Patil, D. M. Mehta, and B. L. Jat, "Life tables of Spodoptera litura," 2014.

[20] G. M. Mascarin, S. B. Alves, and R. B. Lopes, "Culture media selection…," *Brazilian Archives of Biology and Technology*, 2010.
[21] R. Lohse *et al.*, "Endophytic Beauveria fermentation," *AMB Express*, 2014.
[22] A. Ramírez-Godoy *et al.*, "Evaluation of biopesticides," *HortScience*, 2018.
[23] J. G. Ávila-Hernández *et al.*, "Beauveria bassiana secondary metabolites," *Mexican Journal of Biotechnology*, 2020.
[24] D. Kaiser *et al.*, "Co-formulation of Beauveria bassiana…," *Biological Control*, 2020.
[25] G. U. Braga *et al.*, "Effects of UVB on conidia," *Photochemistry and Photobiology*, 2001.
[26] S. A. Pelizza *et al.*, "Effects of oil formulations," *Journal of King Saud University*, 2018.
[27] M. B. González-Maldonado *et al.*, "Control of Spodoptera frugiperda," *Revista Colombiana de Entomología*, 2015.
[28] R. Lohse *et al.*, "Fermentation study," *AMB Express*, 2014.
[29] B. Sawicka *et al.*, "Adjuvants and ecosystems," 2025.
[30] M. M. El-Husseini, "Effect of Beauveria bassiana on Spodoptera," *Egyptian Journal of Biological Pest Control*, 2019.
[31] M. C. Gatarayiha, M. D. Laing, and R. M. Miller, "Field evaluation of Beauveria bassiana," *J. Appl. Entomol.*, 2011.
[32] J. Kumar *et al.*, "Overview of biopesticides," *Plants*, 2021.