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Evaluation of entomopathogenic fungi against diamondback moth larvae in cabbage

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Abstract
Globally, diamondback moth (Plutella xylostella L.) accounts for an estimated US $4-5 billion in annual losses to cruciferous crop production. This research assessed the pathogenicity of four entomopathogenic fungi against P. xylostella larvae on cabbage under laboratory and field settings at Narendra Deva University of Agriculture and Technology, Kumarganj, during rabi 2022 and 2023. Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii, and Isaria fumosorosea were evaluated at three spore concentrations in a completely randomized design for bioassays and a randomized block design for field trials. Under laboratory conditions, B. bassiana at 1×10^8 conidia/ml caused 87.4% larval mortality at 72 hours. In field trials, B. bassiana reduced the larval population by 78.9% at seven days after treatment and produced 28.6 t/ha marketable yield, statistically comparable to spinosad 45 SC (30.2 t/ha). The LC_{50} of B. bassiana was 2.8×10^5 conidia/ml and its LT_{50} was 38.6 hours. These results suggest B. bassiana and M. anisopliae are practical biocontrol candidates for diamondback moth management.

Keywords: Entomopathogenic fungi, diamondback moth, Plutella xylostella, cabbage, Beauveria bassiana, Metarhizium anisopliae, biological control, microbial insecticides, larval mortality, bioassay

Introduction
Nearly 87% of cabbage-growing regions worldwide report diamondback moth infestation, making P. xylostella one of the most widespread pests of cruciferous vegetables [1]. It was also the first pest to develop field resistance to Bacillus thuringiensis toxins [2]. In the Indo-Gangetic plains, cabbage frequently suffers 30-52% yield reductions, and farmers often resort to five or more sprays per season [3]. This heavy chemical dependence has led to resistant populations, destruction of natural enemies, and unacceptable residues [4].
Entomopathogenic fungi act through contact infection rather than ingestion, giving them an advantage against diverse pest types [5]. Species such as B. bassiana and M. anisopliae have shown encouraging results against agricultural pests [6]. The infection begins with conidial attachment to the cuticle, followed by germination, penetration, hemocoel colonization, and host death through nutrient depletion and toxin production [7]. Despite the availability of commercial formulations, field performance can be inconsistent due to temperature and humidity sensitivity [8]. This research compared the virulence of four fungal species against diamondback moth to identify the most effective species and concentration for integration into pest management programmes.

Research Area Description
The field trials were carried out at the Vegetable Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya district, Uttar Pradesh (26.47° N, 81.87° E, 113 m altitude). The region has a subtropical semi-arid climate with mean annual rainfall of 1,050 mm. Soils are alluvial (Typic Ustifluvents) with sandy loam texture and pH 7.6. Diamondback moth pressure is typically high from December through February.

Material and Methods

Material

The research was conducted across two rabi seasons (October 2022 - February 2024) at the location described above. Four entomopathogenic fungi were obtained from NBAIR, Bengaluru: B. bassiana (NBAIR Bb-5a), M. anisopliae (NBAIR Ma-4), L. lecanii (NBAIR Vl-8), and I. fumosorosea (NBAIR If-2). Cultures were mass-produced on rice grain medium and conidia harvested into sterile 0.02% Tween-80 suspension [9]. Concentrations were adjusted to 1×10^6, 1×10^7, and 1×10^8 conidia/ml. Cabbage variety Pride of India was transplanted at 60 × 45 cm in 5 m × 4 m plots [10].

Methods

Laboratory bioassays followed a completely randomized design with five treatments at three concentrations and four replications. Third-instar larvae were sprayed with 2 ml suspension using a Potter's tower at 10 psi. Mortality was recorded at 24, 48, and 72 hours [11]. Field trials used a randomized block design with seven treatments and four replications. Sprays were applied at four larvae per plant threshold. Post-spray counts were made at 3, 7, and 14 days after treatment. Percent reduction was calculated using Henderson-Tilton's formula [12]. LC_{50} and LT_{50} were estimated by probit analysis [13].

Results

Table 1: Larval mortality (%) of diamondback moth at different concentrations of entomopathogenic fungi (72 h post-treatment)

Fungal Species	1×10^6 conidia/ml	1×10^7 conidia/ml	1×10^8 conidia/ml	Mean
Beauveria bassiana	42.6	68.3	87.4	66.1
Metarhizium anisopliae	31.8	54.7	76.2	54.2
Lecanicillium lecanii	24.3	43.1	61.8	43.1
Isaria fumosorosea	18.7	32.6	48.9	33.4
Untreated Control	5.4	5.4	5.4	5.4
SEm(±)	1.83	2.14	2.67	-
CD (P=0.05)	5.49	6.42	8.01	-

B. bassiana was consistently the most virulent, with mortality rising from 42.6% at 1×10^6 to 87.4% at 1×10^8 conidia/ml (Table 1). M. anisopliae peaked at 76.2%. Both L. lecanii and I. fumosorosea remained below 62% and 49% at the highest concentration.

Table 2: Field efficacy of entomopathogenic fungi against diamondback moth at 1×10^8 conidia/ml

Treatment	Pre-spray count	3 DAT Reduction %	7 DAT Reduction %	Yield (t/ha)
B. bassiana	14.7	61.3	78.9	28.6
M. anisopliae	15.2	48.6	67.4	25.3
L. lecanii	14.1	37.8	54.2	22.8
I. fumosorosea	14.9	29.4	43.7	20.4
Spinosad 45 SC	15.3	72.1	84.6	30.2
Untreated	14.5	4.2	6.8	15.7
SEm(±)	-	2.38	3.12	1.24
CD (P=0.05)	-	7.14	9.36	3.72

Under field conditions, B. bassiana achieved 78.9% population reduction by seven days, statistically on par with spinosad at 84.6% (Table 2). Cabbage yields reflected pest control levels, with B. bassiana at 28.6 t/ha compared to 15.7 t/ha untreated.

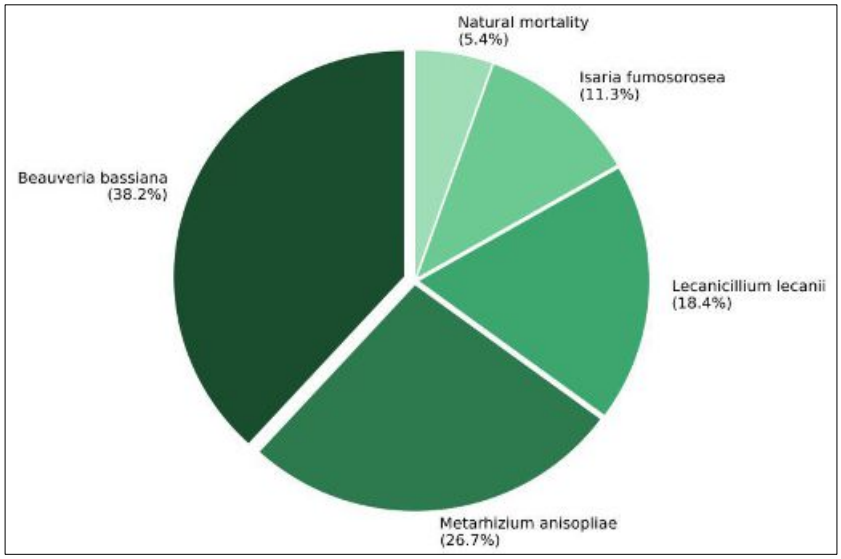

Fig 1: Proportional contribution of each fungal species to total diamondback moth larval mortality under field conditions

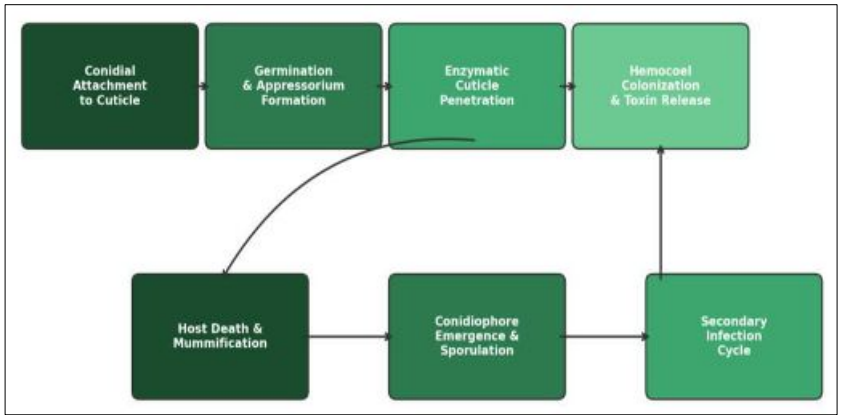

Fig 2: Infection pathway of entomopathogenic fungi in diamondback moth larvae

Comprehensive Interpretation

Probit analysis gave an LC_{50} of 2.8×10^5 conidia/ml for B. bassiana with LT_{50} of 38.6 hours. For M. anisopliae, LC_{50} was 7.4×10^5 and LT_{50} was 46.2 hours, indicating B. bassiana acts faster and requires a lower dose.

Discussion

The superiority of B. bassiana is consistent with literature spanning multiple insect orders [5, 6]. A likely explanation is its broad enzymatic arsenal for cuticle degradation, particularly protease Pr1 and lipase activities [7]. Field performance, while lower than laboratory results, was still encouraging, with the gap smallest for B. bassiana (87.4% vs. 78.9%). The rapid decline in pest numbers between 3 and 7 days after treatment aligns with expected LT_{50} values.

That B. bassiana yields were not statistically different from spinosad makes a strong case for inclusion in resistance management programmes. Rotating B. bassiana with spinosad could slow resistance evolution. Biological agents also offer residual effects through secondary infection cycles, an advantage unavailable with synthetic products [14]. Their compatibility with commonly used fungicides and herbicides has been established [15], making them feasible components of integrated management.

Conclusion

B. bassiana at 1×10^8 conidia/ml emerged as the top performer both in laboratory bioassays and field trials, with outcomes statistically comparable to spinosad. M. anisopliae is a viable alternative. Farmers should apply B. bassiana sprays in late afternoon when UV exposure is lower and target early larval instars. Integration with selective chemical insecticides in rotation can extend the useful life of both tools while reducing chemical burden on the crop and environment.

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