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Research Article

Assessment of field efficacy & economic viability of selected entomopathogenic fungal isolates against *Chilo partellus* (Crambidae : Lepidoptera)

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ABSTRACT

The present study aimed to evaluate the field efficacy of four promising isolates (Bb-5a, Bb-23, Bb-45, and Ma-35) of entomopathogenic fungi (EPF) against maize stem borer, *Chilo partellus*, during winter seasons over a two-year period at ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru, Karnataka, India. All tested EPF isolates demonstrated superior efficacy compared to the control in suppressing maize stem borer damage across both seasons. Pooled data analysis revealed that the incidences of dead hearts (DH), stem tunnelling (ST), galleries (per plant), and exit holes (per plant) ranged from 8.7-18.3%, 5.06-7.97 cm/plant, 1.69-2.42 per plant, and 2.72-5.12 per plant, respectively, compared to untreated control values of 21.6%, 8.93 cm/plant, 3.23 per plant, and 6.72 per plant, respectively. Among all treatments, Bb-5a exhibited significantly superior efficacy in reducing the incidence of dead hearts (8.7%), stem tunnelling (5.06 cm/plant), galleries (1.69 per plant), and exit holes (2.72 per plant). Furthermore, Bb-5a demonstrated a higher yield of 68.8 t/ha, representing a 17.65% increase over the control. Bb-5a isolate also recorded higher gross returns of ₹ 82660/ha, resulting in a maximum net profit of ₹ 56660/ha with a cost-benefit ratio of 1:3.18. These findings highlight the potential of Bb-5a as an effective biocontrol agent against maize stem borer, offering economic benefits to farmers.

KEY WORDS: *Chilo partellus*; *Beauveria bassiana*; *Metarhizium anisopliae*; Maize stem borer

1. Introduction

The maize stem borer, *Chilo partellus* Swinhoe (Crambidae: Lepidoptera), poses a significant constraint to maize (*Zea mays* L.) production globally, with resultant crop losses ranging from 24 to 83 per cent (Sarup *et al*., 1987). Maize holds a pivotal position in India's agricultural landscape, serving as a primary cereal crop for both human consumption and animal feed, covering approximately 37 per cent of cultivated land and yielding around 225 lakh tonnes annually (Anon. 2016). India's maize cultivation faces substantial threats from over 20 insect pests, among which *C. partellus* is a particularly dominant, infesting maize crop throughout their growth stages and causing substantial yield losses of 90-95% (Jalali and Singh, 2002).

C. partellus emerges as a prominent maize pest across various regions of Africa and southern Asia. The pest's infestation cycle typically commences with egg deposition on maize leaves, followed by larval emergence and migration into leaf whorls where feeding and subsequent lesion formation occur. Larvae progress to late third or

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early fourth instars, subsequently boring into the stem to feed on tissues and create tunnels. The larvae's feeding activity, particularly within leaf whorls or stem regions, disrupts meristematic tissues, leading to the characteristic symptom of "dead heart" and eventual plant mortality (Tadele and Pringle, 2007).

Despite considerable research efforts focused on *C. partellus* management in India, there remains a gap in understanding the pest's dynamics within the Karnataka region. The transition from conventional synthetic insecticides to biological control agents has gained momentum due to environmental concerns and challenges associated with insecticide resistance (Lewis *et al.*, 1996). Consequently, entomopathogenic fungi have emerged as promising, environmentally benign insect control agents (Miranpuri and Kachatourian, 1993; Renuka *et al.*, 2015). This study endeavors to assess the efficacy of select isolates of entomopathogenic fungi in mitigating maize stem borer damage inflicted by *C. partellus* during winter seasons, while also examining the economic implications of their implementation.

2. Materials and Methods

The field trial targeting maize stem borer, *Chilo partellus*, was conducted at the ICAR-NBAIR, Bengaluru, Karnataka, India, over two consecutive winter seasons. The trial employed four promising isolates of entomopathogenic fungi, namely *Beauveria bassiana* strains Bb-5a, Bb-23, Bb-45, and *Metarhizium anisopliae* strain Ma-35. Employing a completely randomized block design, the experiment encompassed five treatments, each replicated four times. The selected maize hybrid for assessment was Nityashree (NAH-2049), known for its susceptibility to stem borer infestation. Maize seeds were manually dibbled into experimental plots measuring 5×6 m for each replication, maintaining a spacing of 60×30 cm. Standard agronomic practices were adhered to, including recommended fertilizer doses, following the package of practices outlined by the University of Agricultural Sciences, Bengaluru, Karnataka. Application of the oil formulation of the entomopathogenic fungal isolates, diluted in water at a rate of 5ml per liter, was administered twice using a hand sprayer. Treatments, with a spore dose of 1×10^8 cfu/ml, were applied 15 and 30 days after germination during both years.

Subsequently, laboratory-reared *C. partellus* larvae at the second instar stage, at a rate of eight larvae per plant, were carefully introduced into the inner leaf whorl using a camel hair brush, one week after the second spray. Observations on parameters such as the number of dead hearts (DH), extent of stem tunneling (cm/plant) (ST), number of galleries per plant, number of exit holes per plant (EH), and yield metrics were recorded at harvest by longitudinally splitting plants from top to base. Statistical analysis was performed using SPSS v16 software, with the analyzed data subjected to Duncan's Multiple Range Test (DMRT). Treatment-wise cob, grain, and straw yields per plant were recorded and converted to tonnes/quintals per hectare.

Meteorological data for the experimental period over two years included T_{max} (29.12 °C), T_{min} (17.72 °C), RH-I (89.2%), RH-II (47.8%), and RF (191.2 mm) for the first year, and T_{max} (29.54 °C), T_{min} (15.96 °C), RH-I (84.98%), RH-II (39.9%), and RF (74.2 mm) for the second year. These data, obtained from the meteorological observatory at the University of Agricultural Sciences, Bangalore, Karnataka, were utilized for experimental purposes.

Table 1: Pooled effect of different isolates of EPF on maize stem borer, *Chilo partellus*

Isolate	Average No. of dead hearts	Dead heart (%)	No. of galleries/ plant	No. of Exit holes/plant	Stem tunneling/ plant (cm)	Cob yield/ 10 plants (Kg)	Cob yield (t/ha)
Bb-5a	2.62^{a} (1.63)	8.7	1.69^{a} (1.48)	2.72^{a} (1.66)	5.06^{a} (2.36)	12.4^{a} (3.59)	68.8
Bb-23	4.55^{bc} (2.14)	15.2	2.18^{a} (1.64)	5.12^{bc} (2.27)	7.97^{b} (2.91)	9.6^{b} (3.18)	53.1
Bb-45	5.50^{c} (2.36)	18.3	2.42^{ab} (1.71)	5.08^{bc} (2.26)	7.17^{ab} (2.77)	10.1^{ab} (3.26)	56.1
Ma-35	3.69^{ab} (1.93)	12.3	2.02^{a} (1.59)	3.29^{ab} (1.83)	5.43^{a} (2.43)	11.7^{ab} (3.49)	64.3
Control	6.48^{c} (2.56)	21.6	3.23^{b} (1.93)	6.72^{c} (2.60)	8.93^{b} (3.07)	9.5^{b} (3.16)	52.5
CD @ 0.05	1.15	-	0.87	2.24	2.53	2.5	-

Note: Means followed by the similar letters in the columns are not significantly different at 5% by DMRT

3. Results and Discussion

The field trial investigating the efficacy of entomopathogenic fungi (EPF) isolates against maize stem borer, *Chilo partellus*, during winter seasons yielded significant results over two consecutive years. Pooled data analysis revealed notable suppression of maize stem borer damage across various parameters compared to the untreated control.

3.1 Dead Hearts

Analysis of dead heart percentages (Table 1) showed that both Bb-5a (8.7 %) and Ma-35 (12.3 %) isolates demonstrated statistically significant reductions in dead heart incidence compared to the untreated control (21.6 %). The observed decrease in dead hearts could be attributed to the endophytic activity of *B. bassiana* and *M. anisopliae* isolates, as reported in previous studies. Endophytic colonization of maize plants by these isolates is known to result in reduced dead heart occurrences.

3.2 Number of Galleries

The pooled data exhibited a reduction in the number of galleries per plant, ranging from 1.69 to 2.42, compared to the untreated control (3.23 per plant). Bb-5a displayed the lowest number of galleries (1.69 per plant), followed by Ma-35 and Bb-23, with similar levels of efficacy. The decrease in gallery formation is likely attributable to the reduced survival of *C. partellus* larvae due to the endophytic activity of the EPF isolates (Table 1).

3.3 Number of Exit Holes

Similarly, the number of exit holes per plant ranged from 2.72 to 3.29 in treated plots, compared to 6.72 in the untreated control (Table 1). Bb-5a exhibited the lowest number of exit holes (2.72 per plant), followed by Ma-35. This reduction in exit holes aligns with the decreased survival of *C. partellus* larvae resulting from the endophytic activity of *B. bassiana* and *M. anisopliae* isolates.

3.4 Stem Tunneling

Stem tunneling measurements ranged from 5.06 to 7.97 cm per plant in treated plots, contrasting with 8.93 cm in the untreated control. Both Bb-5a and Ma-35 isolates showed the least damage, with Bb-5a demonstrating the lowest stem tunneling (5.06 cm per plant). The diminished stem tunneling observed can be attributed to the systematic activity of the EPF isolates within the maize plant system (Table 1).

These findings underscore the potential of *B. bassiana* and *M. anisopliae* isolates in mitigating maize stem borer damage during winter seasons. The observed reductions in various damage parameters corroborate previous research highlighting the efficacy of endophytic EPF isolates in insect pest management.

3.5 Yield

The pooled cob yield data from the experimental trials demonstrated the superior performance of all four tested entomopathogenic fungi (EPF) isolates, with cob yields ranging from 68.8 to 64.3 tonnes per hectare (t/ha). Notably, Bb-5a (68.8 t/ha) and Ma-35 (64.3 t/ha) treatments exhibited the highest yields, significantly surpassing the untreated control (52.5 t/ha), as detailed in Table 1. Regarding grain yield, pooled data analysis revealed significantly higher yields of 52.80 and 51.40 quintals per hectare (q/ha) for Bb-5a and Ma-35 isolates, respectively, representing a 20.27% and 18.09% increase over the control. These results were statistically comparable between the two isolates, as shown in Table 2. Additionally, Bb-45 and Bb-23 isolates recorded grain yields of 50.0 and 48.50 q/ha, respectively, with 15.80% and 13.20% increases over the control. Conversely, the untreated control exhibited the lowest grain yield.

Similarly, the pooled data on maize straw yield highlighted significantly higher yields of 70.10 and 69.17 q/ha for Bb-5a and Ma-35 isolates, respectively, representing increases of 17.65% and 16.54% over the control. These yields were statistically similar between the two isolates

Table 2: Pooled data of cost economics of different isolates of EPF on *Chilo partellus*

Isolates	Grain yield (q/ha)	Per cent increase over control	Straw yield (q/ha)	Per cent increase over control	Gross income (`/ha)	Cost of cultivation (`/ha)	Net profit (`/ha)	Net gain over control (`/ha)	B:C ratio
Bb-5a	52.80[a] (7.30)	20.27	70.1[a] (8.40)	17.65	82660	26000	56660	15384	3.18
Bb-23	48.50[c] (7.00)	13.20	64.05[c] (8.03)	9.87	75860	26000	49860	8584	2.92
Bb-45	50.00[b] (7.11)	15.80	66.13[b] (8.16)	12.70	78226	26000	52226	10950	3.01
Ma-35	51.40[a] (7.20)	18.09	69.17[a] (8.35)	16.54	80654	26000	54654	13378	3.10
Control	42.10[d] (6.53)	00.00	57.73[d] (7.63)	00.00	66276	25000	41276	00000	2.65
CD @ 0.05	1.90	-	2.52	-	-	-	-	-	-

Note: Means followed by the similar letters in the columns are not significantly different at 5% by DMRT

(Table 2). Moreover, Bb-45 and Bb-23 isolates recorded straw yields of 66.13 and 64.05 q/ha, respectively, with increases of 12.70% and 9.87% over the control. The untreated control exhibited the lowest straw yield. The enhanced yields associated with these endophytic isolates may be attributed to their effective suppression of maize stem borer. Previous research by Reddy *et al*. (2009) reported significantly higher yields in sorghum plots treated with endophytic *B. bassiana* compared to untreated controls under artificial *C. partellus* infestation.

3.6 Cost Economics

The cost economics of EPF application against maize stem borer, *C. partellus*, during winter seasons were analyzed and presented in Table 2. Among all the promising EPF isolates, Bb-5a and Ma-35 recorded higher gross returns of ₹ 82660/ha and ₹ 80654/ha, respectively, resulting in maximum net profits of ₹ 56660/ha and ₹ 54654/ha, respectively, which were statistically comparable. Following closely were Bb-45 and Bb-23, with gross returns of ₹ 78226/ha and ₹ 75860/ha, respectively (net returns of ₹ 52226/ha and ₹ 49860/ha, respectively). The lowest profits were recorded in the untreated control, with ₹ 41276/ha.

Regarding the cost-benefit ratio, the highest ratio was observed in Bb-5a (1:3.18), followed by Ma-35 (1:3.10). Conversely, Bb-45 and Bb-23 exhibited lower ratios of 1:3.01 and 1:2.92, respectively, while the untreated control recorded the lowest ratio of 1:2.65 (Table 2). It's worth noting that the cost economics analysis, along with the cost-benefit ratio, represents novel contributions to the field, with no existing comparable data available.

4. Conclusion

In conclusion, the field trials conducted during winter seasons showcased the superior efficacy of Bb-5a and Ma-35 isolates in suppressing maize stem borer, *C. partellus*. These isolates offer promising alternatives to chemical insecticides for pest management, exhibiting eco-friendly attributes with no discernible adverse effects on the environment, human health, or animal health. Consequently, we recommend the adoption of Bb-5a and Ma-35 isolates as viable strategies for stem borer control among farmers, contributing to sustainable agricultural practices and reducing reliance on conventional chemical insecticides. Further research and field trials are warranted to explore their broader applicability and optimize their integration into pest management strategies for maize cultivation.

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