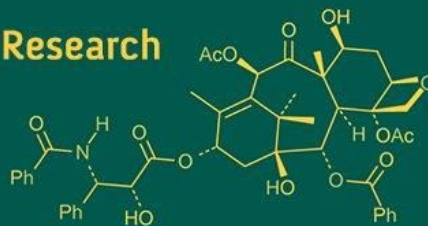
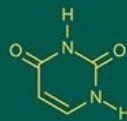
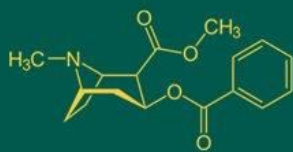


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Evaluation of bio-efficacy for different entomopathogens against rice insect pests

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Abstract

The field experiment was conducted at the research cum instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.) during *Kharif* season of 2024 to evaluate the bio-efficacy for different entomopathogens against rice insect pests. Eight different treatments were applied at 50, 65 and 80 days after transplanting (DAT). The pre and post treatment observations were recorded at 7 and 14 days after spraying (DAS) on the rice variety 'Swarna'. Among all the treatments, (T₄) *Bacillus thuringiensis* applied @ 1 kg/ha was found as most effective in reducing stem borer dead hearts and white ear head damage, which was followed by (T₇) Cartap hydrochloride @ 20kg/ha. The lowest percent leaf damage of rice leaf folder was observed in (T₄) *Bacillus thuringiensis* @ 1kg/ha treated plots followed by (T₅) *Metarhizium anisopliae* @ 1kg/ha which is statistically at par with each other. For reducing the infestation of brown plant hopper (T₅) *Metarhizium anisopliae* @ 1kg/ha was found effective followed by (T₇) Cartap hydrochloride @ 20 kg/ha. However, in case of whorl maggot at 7 DAS of first round spray *Bacillus thuringiensis* @ 1kg/ha (T₄) was found significantly superior to untreated control but no incidence was observed after 14 DAS of first spray. Traces amount of leaf damage was observed in case of rice hispa in pre and post treatment observations. The highest grain yield among all the treatment was recorded for *Metarhizium anisopliae* @ 1kg/ha (T₅) i.e. 62.31 q/ha followed by (T₆) *Beauveria bassiana* @ 1kg/ha with 55.19 q/ha. The lowest grain yield of 38.50 q/ha was obtained in untreated control.

Keywords: Bio-efficacy, entomopathogens, rice insect pests, *Bacillus thuringiensis*

Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops and has been cultivated since ancient times to sustain human populations. It serves as the primary food source for over half of the world's growing population. The crop is grown under a wide range of agroclimatic conditions, from hilly terrains to coastal regions. Although predominantly a kharif season crop, rice is grown throughout the year in various parts of the country (Shivappa *et al.*, 2021)^[10]. In India during 2023-24, rice is cultivated over a total area of 478.28 lakh hectares yielding an annual production of 1378.25 lakh tonnes with an average productivity of 2882 kg/hectare (Anonymous, 2024)^[1].

Rice crop is attacked by more than hundred insect species, though only a few of them cause serious economic damage. These harmful insect pests represent a major obstacle to achieving high rice yields (Rai *et al.*, 2000)^[8]. Among the most damaging pests in India are stem borers, gall midge (*Orseolia oryzae*), brown planthopper (*Nilaparvata lugens* Stal.), leaf folder (*Cnaphalocrocis medinalis*), and green leafhopper (*Nephotettix virescens*). These pests frequently pose challenges across diverse rice-growing environments (Muralidharan and Pasalu, 2006)^[7]. Particularly destructive are the stem borers and brown planthoppers, which inflict serious yield losses during the later growth stages of the crop.

Rice insect pests have many natural enemies, including various predators and parasitoids that play a key role in biological control. Predation is widespread among insects, and some of the most effective biological control efforts have been achieved through the use of predators. These predators include different types of spiders and insects such as staphylinid beetles, coccinellid beetles (commonly known as ladybird beetles), as well as both aquatic and land-based predatory bugs, damselflies, and dragonflies.

While the widespread use of synthetic insecticides has played a role in enhancing food production, it has also caused negative environmental effects and harmed non-target

organisms. Beneficial insects, including natural predators and parasitoids found in rice ecosystems, are often more vulnerable to these chemicals. In contrast, entomopathogens offer a sustainable and environmentally friendly method of pest control. These biological agents, which include bacteria, fungi, viruses, protozoa, and nematodes, can infect a wide range of insect hosts and often lead to natural outbreaks of disease among pest populations (Reddy *et al.*, 2013) [9].

Considering the importance of entomopathogens in minimizing insect pests population, this study was undertaken to evaluate the bio-efficacy for different entomopathogens against rice insect pests.

Materials and Methods

Table 1: Treatment details

S. No.	Treatments	Dose (ml or gm) / litre of water	Dose (Kg or l) / ha.
1.	<i>Bacillus albus</i> NBAIR-BATP (1×10 ⁸ cfu/ml)	10ml/l	5l /ha.
2.	<i>Metarhizium anisopliae</i> NBAIR-Ma35(1×10 ⁸ cfu/ml)	10ml/l	5l /ha.
3.	<i>Beauveria bassiana</i> NBAIR-Bb5a (1×10 ⁸ cfu/ml)	10ml/l	5l /ha.
4.	<i>Bacillus thuringiensis</i> NRRI-TB 261 (1×10 ⁸ cfu/ml)	2gm/l	1kg /ha.
5.	<i>Metarhizium anisopliae</i> NRRI-TF 9 (1×10 ⁸ cfu/ml)	2gm/l	1kg/ha.
6.	<i>Beauveria bassiana</i> NRRI- TF 6 (1×10 ⁸ cfu/ml)	2gm/l	1kg/ha.
7.	Cartap hydrochloride 4G	40gm/plot	20kg/ha.
8.	Untreated	-	-

(Source: IIRR (ICAR), Hyderabad)

Observations recorded

The incidence of insect pest infestation was assessed on the basis of dead hearts (DH) and white ear heads (WEH) caused by yellow stem borer and damaged or folded leaves caused by leaf folder, whorl maggot and rice hispa in all the experimental plots. The incidence of brown planthopper (BPH) was recorded on the basis of total number of nymphs and adults. The observations were recorded on 10 randomly selected hills in each treatment and replication on the basis of following formula proposed by Heinrichs *et al.*, 1985 [4].

$$\% \text{ Deadheart} = \frac{\text{Number of dead hearts}}{\text{Total number of tillers}} \times 100$$

$$\% \text{ White ear heads} = \frac{\text{Number of white ear heads}}{\text{Total number of panicles}} \times 100$$

$$\% \text{ Leaf incidence} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Data analysis

The data were analyzed statistically by using appropriate arc-sine and square root transformation wherever necessary. Standard statistical procedure was followed as per Gomez and Gomez (1984) [3].

Results and Discussion

Stem borer (*Scirpophaga incertulas*)

The incidence of yellow stem borer was recorded one day before and 7 and 14 days after each spraying. The lowest percent of dead heart was recorded in (T₄) *Bacillus thuringiensis* @ 1kg/ha treated plots followed by (T₇) Cartap hydrochloride @ 20kg/ha. The highest reduction of stem borer dead heart over control was observed in (T₄) *Bacillus thuringiensis* @ 1kg/ha with 59.80%.

Data on white ear head incidence was recorded before the harvesting of crop (125 DAT), ranged from 12.75% to

The field experiment was carried out at the research cum instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.) during kharif season of 2024. The experiment was laid out in randomized block design with eight treatments and four replications including untreated control. Six entomopathogens and one insecticide were used in the experiment.

The treatments were applied thrice at 50, 65 and 80 days after transplanting with knapsack sprayer using 500L/ha spray fluid on initiation of pest population. The population of insect pests i.e. stem borer, leaf folder, rice hispa, whorl maggot and brown planthopper was recorded one day prior and 7 and 14 days after each spraying. The pre-treatment and post-treatment observations were recorded on ten randomly selected hills in each treatment and replication.

15.43% in different treatments showed significant differences over untreated control. *Bacillus thuringiensis* @ 1 kg/ha (T₄) showed significantly minimum incidence (12.75%) of stem borer white ear heads and was at par with (T₃) *Beauveria bassiana* @ 5l/ha (13.04%). Maximum incidence of white ear heads (15.43%) was observed in untreated control.

On the basis of overall impact of treatment application, (T₄) *Bacillus thuringiensis* applied @ 1 kg/ha was found as the most effective in reducing stem borer dead hearts and white ear heads which was followed by (T₇) Cartap hydrochloride @ 20kg/ha.

The present findings are in confirmation with the findings of Chatterjee and Mondal, (2014) [2] reported that among the biopesticides, *Bacillus thuringiensis* was most effective in reducing dead heart and white ear head of yellow stem borer.

Leaf folder (*Cnaphalocrocis medinalis*)

The lowest percent of leaf damage was recorded in (T₄) *Bacillus thuringiensis* @ 1kg/ha treated plots followed by (T₅) *Metarhizium anisopliae* @ 1kg/ha. The highest reduction over control was found in (T₄) *Bacillus thuringiensis* @ 1kg/ha (79.45%). *Bacillus thuringiensis* proved to be most effective for controlling leaf folder among all treatments.

The present findings are with the confirmation of Kandibane *et al.*, 2010 [5] reported that the B.t. formulation effectively reduced leaf folder damage and increased grain yield.

Brown planthopper (*Nilaparvata lugens*)

The lowest infestation of BPH was found in (T₅) *Metarhizium anisopliae* @ 1kg/ha treated plots which was followed by (T₇) Cartap hydrochloride @ 20 kg/ha. The highest infestation of BPH was found in the untreated control plots. The highest percent of reduction over control was also found in *Metarhizium anisopliae* @ 1kg/ha.

The present findings are in confirmation with the findings of Reddy *et al.* (2013) ^[9] reported that among the entomopathogens, *B. bassiana*, and *M. anisopliae* were found to be relatively more effective against BPH and relatively less toxic to predators, followed by *V. lecani*. Kumar and Singh (2021) ^[6] observed that Imidacloprid 17.8 SC @ 200 ml/ha were found most effective in comparison to all other treatments and *Metarhizium anisopliae* 4.7 × 10% c.f.u./gm @ 2.5 kg/ha gave the best result among all bio-pesticides.

Whorl maggot (*Hydrellia philipinna*) and Rice hispa (*Dicladisa armigera*)

The whorl maggot percent was ranged from 1.13 to 2.12% in the pre-treatment observations and was statistically non-significant.

After seven days of first spray, *Bacillus thuringiensis* @ 1kg/ha was statistically significant over untreated control with the minimum incidence of whorl maggot (1.06%) which was at par with *Beauveria bassiana* @ 5L/ha (1.07%). Whereas, highest whorl maggot incidence (2.30%) had been under untreated control.

After fourteen days of first spray, the incidence of whorl maggot was drastically decreased as the paddy crop recovered all the damage which was occurred by whorl maggot. Further observations were not taken as the incidence of whorl maggot was not observed.

Singh and Chatterjee (2021) ^[11] reported that the lowest percent of whorl maggot was recorded in spinosad treated plots followed by *B. thuringiensis* var. *kurstaki* treatment and azadirachtin treatment respectively.

The rice hispa percent was ranged from 1.83 to 2.95% in the pre-treatment observations and was statistically non-significant. The post treatment observations were statistically non-significant as trace amounts of leaf damage by rice hispa was observed.

Grain yield

All the treatments resulted in higher grain yields compared to the untreated control, indicating their overall superiority. Among them, the highest grain yield of 62.31 q/ha was recorded in treatment *Metarhizium anisopliae* @ 1kg/ha (T₅), followed by (T₆) *Beauveria bassiana* @ 1kg/ha with a yield of 55.19 q/ha.

Table 2: Relative increase in yield under different treatments

T. No.	Treatments details	Dose (kg or l)/ha	Grain yield (q/ha.)	Increase in yield over control (q/ha.)
T ₁	<i>Bacillus albus</i> NBAIR-BATP	5l /ha.	44.88	6.38
T ₂	<i>Metarhizium anisopliae</i> NBAIR-Ma35	5l /ha.	48.63	10.13
T ₃	<i>Beauveria bassiana</i> NBAIR-Bb5a	5l /ha.	49.38	10.88
T ₄	<i>Bacillus thuringiensis</i> NRRI-TB 261	1kg /ha.	50.06	11.56
T ₅	<i>Metarhizium anisopliae</i> NRRI-TF 9	1kg/ha.	62.31	23.81
T ₆	<i>Beauveria bassiana</i> NRRI- TF 6	1kg/ha.	55.19	16.69
T ₇	Cartap hydrochloride 4G	20kg/ha.	44.31	5.81
T ₈	Untreated	-	38.50	-

Table 3: Effect of treatment application on the incidence of stem borer dead heart damage during *kharif*, 2024

T. No.	Dose (kg or l)/ha	Percent dead hearts/ hill										Overall mean	Percent reduction over control
		Pre- treatment	Post-treatment										
			1 st application			2 nd application			3 rd application				
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean		
T ₁	5l /ha.	9.71 (18.04)	8.79 (17.18)	8.42 (16.81)	8.60	7.51 (15.85)	6.45 (14.66)	6.98	5.70 (13.80)	0	2.85	6.14	53.70
T ₂	5l /ha.	9.01 (17.45)	8.46 (16.88)	8.17 (16.57)	8.32	7.39 (15.73)	6.27 (14.46)	6.83	6.00 (14.16)	0	3.00	6.05	54.37
T ₃	5l /ha.	8.26 (16.64)	8.21 (16.62)	7.95 (16.36)	8.08	7.03 (15.36)	5.94 (14.09)	6.48	5.97 (14.11)	0	2.98	5.85	55.88
T ₄	1kg /ha.	8.99 (17.32)	7.96 (16.23)	7.19 (15.43)	7.57	6.30 (14.42)	5.75 (13.78)	6.02	4.77 (12.52)	0	2.38	5.33	59.80
T ₅	1kg/ha.	9.88 (18.18)	8.79 (17.14)	7.86 (16.21)	8.32	6.42 (14.59)	5.77 (13.79)	6.09	5.26 (13.19)	0	2.63	5.68	57.16
T ₆	1kg/ha.	8.75 (17.11)	8.76 (17.19)	8.34 (16.77)	8.55	7.48 (15.84)	6.84 (15.13)	7.16	5.29 (13.27)	0	2.65	6.12	53.85
T ₇	20kg/ha.	8.41 (16.72)	7.93 (16.22)	7.13 (15.34)	7.53	6.65 (14.84)	5.87 (13.92)	6.26	4.70 (12.46)	0	2.35	5.38	59.43
T ₈	-	7.88 (16.21)	15.51 (23.13)	17.21 (24.49)	16.36	18.40 (25.39)	16.39 (23.85)	17.40	12.05 (20.23)	0	6.03	13.26	-
C.D. @ 5%		N.S.	2.761	2.105	-	1.864	2.083	-	1.881	N.S.	-	-	-
C.V.		8.78	10.613	8.243	-	7.63	9.101	-	8.939	-	-	-	-

Figures in parentheses are arcsine transformed values, NS- Non significant, DAS- Days after spray

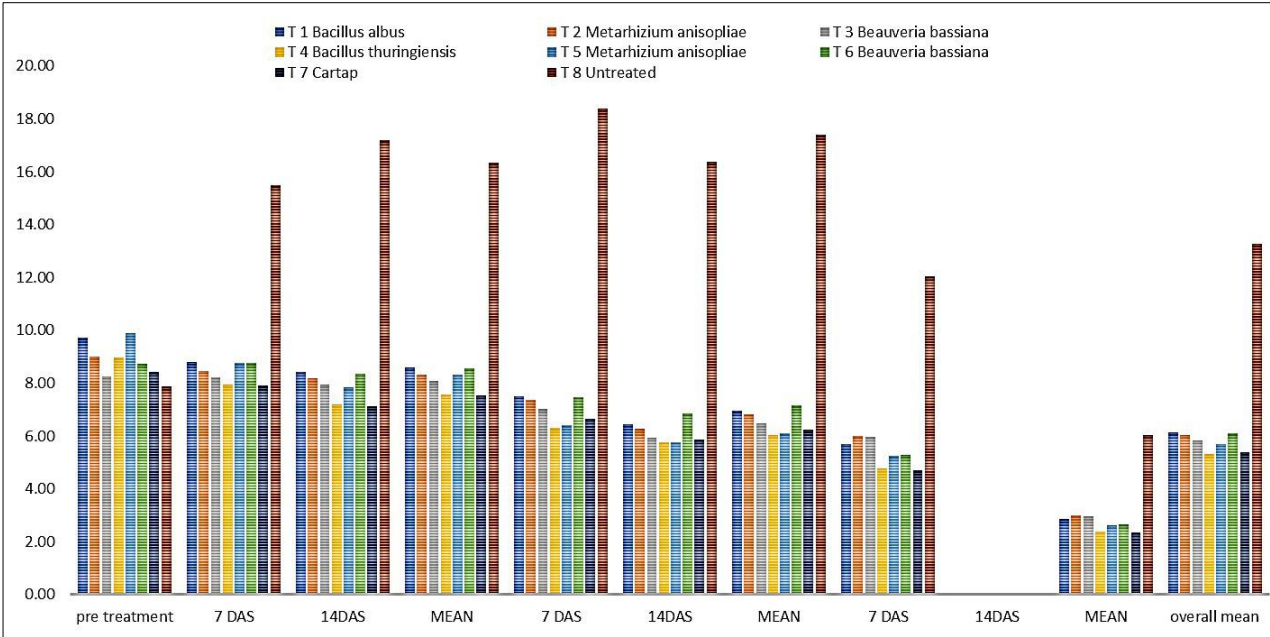


Fig 1: Effect of treatment application on the incidence of stem borer dead heart damage during kharif, 2024

Table 4: Effect of treatment application on the incidence of stem borer white ear head damage during kharif, 2024

T. No.	Treatments details	Dose (kg or l)/ha	Percent White ear head/hill	Percent reduction over control
T ₁	<i>Bacillus albus</i> NBAIR-BATP	5l /ha.	13.48 (21.52)	12.64
T ₂	<i>Metarhizium anisopliae</i> NBAIR-Ma35	5l /ha.	14.29 (22.20)	7.39
T ₃	<i>Beauveria bassiana</i> NBAIR-Bb5a	5l /ha.	13.04 (21.16)	15.49
T ₄	<i>Bacillus thuringiensis</i> NRRI-TB 261	1kg /ha.	12.75 (20.91)	17.37
T ₅	<i>Metarhizium anisopliae</i> NRRI-TF 9	1kg/ha.	13.73 (21.74)	11.02
T ₆	<i>Beauveria bassiana</i> NRRI- TF 6	1kg/ha.	13.50 (21.54)	12.51
T ₇	Cartap hydrochloride 4G	20kg/ha.	13.91 (21.88)	9.85
T ₈	Untreated	-	15.43 (23.11)	-
C.D. @ 5%			0.91	
C.V.			2.825	

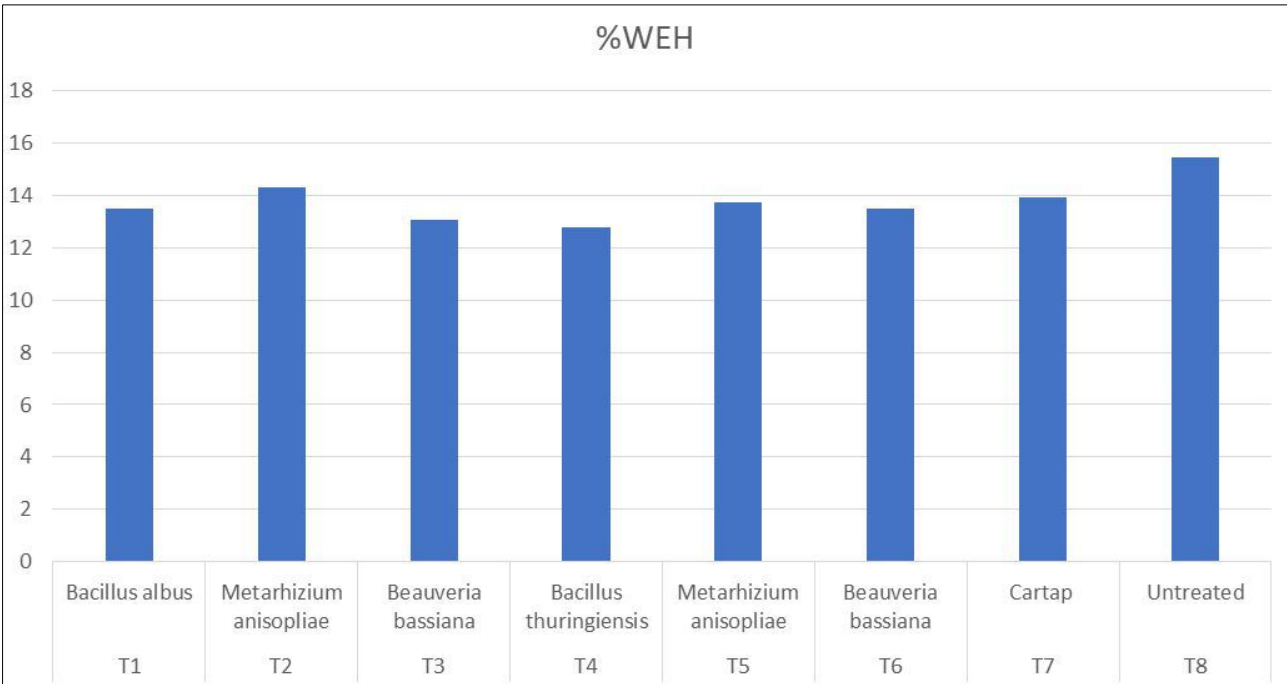
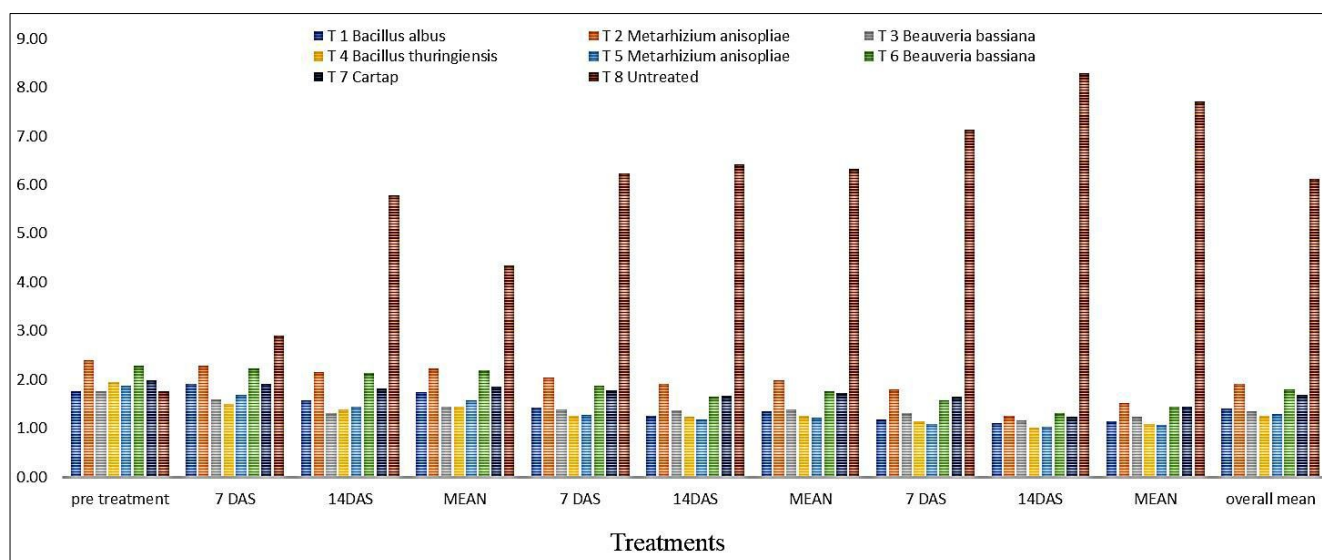


Fig 2: Effect of treatment application on the incidence of stem borer white ear head damage during kharif, 2024

Table 5: Effect of treatment application on the incidence of leaf folder damage during *kharif*, 2024

T. No.	Dose (kg or l)/ha	Percent of leaf damage/ hill										Overall mean	Percent reduction over control
		Pre-treatment	Post-treatment										
			1 st application			2 nd application			3 rd application				
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean		
T ₁	5l /ha.	1.76 (7.60)	1.91 (7.91)	1.57 (7.16)	1.74	1.44 (6.85)	1.25 (6.41)	1.34	1.18 (6.21)	1.12 (6.06)	1.15	1.41	77.00
T ₂	5l /ha.	2.39 (8.86)	2.29 (8.58)	2.16 (8.43)	2.23	2.04 (8.20)	1.92 (7.95)	1.98	1.79 (7.68)	1.26 (6.44)	1.53	1.91	68.84
T ₃	5l /ha.	1.77 (7.62)	1.60 (7.24)	1.31 (6.54)	1.45	1.40 (6.77)	1.38 (6.72)	1.39	1.31 (6.51)	1.17 (6.13)	1.24	1.36	77.81
T ₄	1kg /ha.	1.95 (7.99)	1.50 (7.02)	1.39 (6.77)	1.45	1.27 (6.43)	1.24 (6.39)	1.25	1.15 (6.13)	1.02 (5.70)	1.08	1.26	79.45
T ₅	1kg/ha.	1.87 (7.82)	1.69 (7.44)	1.45 (6.88)	1.57	1.28 (6.45)	1.19 (6.23)	1.23	1.10 (6.01)	1.04 (5.85)	1.07	1.29	78.96
T ₆	1kg/ha.	2.28 (8.68)	2.23 (8.58)	2.14 (8.39)	2.19	1.88 (7.88)	1.66 (7.34)	1.77	1.59 (7.21)	1.31 (6.56)	1.45	1.80	70.64
T ₇	20kg/ha.	1.98 (7.86)	1.92 (7.93)	1.81 (7.73)	1.87	1.78 (7.65)	1.68 (7.42)	1.73	1.66 (7.36)	1.25 (6.37)	1.45	1.68	72.59
T ₈	-	1.76 (7.54)	2.90 (9.77)	5.79 (13.89)	4.35	6.24 (14.41)	6.42 (14.64)	6.33	7.13 (15.43)	8.29 (16.53)	7.71	6.13	-
C.D. @ 5%		N.S.	1.276	1.035		1.123	0.951		1.211	1.956			
C.V.		12.594	10.697	8.5		9.393	8.145		10.466	17.726			

Figures in parentheses are arcsine transformed values, NS- Non significant, DAS- Days after spray

**Fig 3:** Effect of treatment application in the incidence of leaf damage due to leaf folder during *kharif*, 2024**Table 6:** Effect of treatment application on the incidence of Brown plant hopper during *kharif*, 2024

T. no.	Dose (kg or l)/ha	Population of BPH/ hill										Overall mean	Reduction over control %
		Pre- treatment	Post-treatment										
			1 st application			2 nd application			3 rd application				
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean		
T ₁	5L /ha.	11.25 (3.49)	10.75 (3.43)	10.00 (3.32)	10.38	9.00 (3.16)	8.00 (3.00)	8.50	7.75 (2.95)	5.00 (2.45)	6.38	8.42	50.47
T ₂	5L /ha.	11.75 (3.57)	10.25 (3.35)	10.00 (3.32)	10.13	9.25 (3.20)	7.50 (2.91)	8.38	7.25 (2.87)	4.50(2.34)	5.88	8.13	52.18
T ₃	5L /ha.	13.00 (3.73)	11.50 (3.52)	10.25 (3.34)	10.88	9.50 (3.23)	8.75 (3.11)	9.13	8.25 (3.04)	4.25 (2.28)	6.25	8.75	48.53
T ₄	1kg /ha.	11.25 (3.50)	10.50 (3.39)	10.00 (3.32)	10.25	9.25 (3.19)	8.50 (3.08)	8.88	8.00 (3.00)	3.75 (2.18)	5.88	8.33	51.00
T ₅	1kg/ha.	13.00 (3.72)	11.25 (3.49)	9.25 (3.20)	10.25	7.75 (2.96)	6.50 (2.73)	7.13	5.75 (2.59)	2.50 (1.87)	4.13	7.17	57.82
T ₆	1kg/ha.	11.25 (3.49)	10.00 (3.31)	9.75 (3.27)	9.88	8.75 (3.12)	7.25 (2.87)	8.00	7.25 (2.87)	3.25 (2.06)	5.25	7.71	54.65
T ₇	20kg/ha.	10.75 (3.39)	10.25 (3.34)	9.50 (3.23)	9.88	8.25 (3.04)	7.00 (2.82)	7.63	6.50 (2.73)	2.75 (1.93)	4.63	7.38	56.59
T ₈	-	14.50 (3.93)	18.50 (4.41)	19.25 (4.50)	18.88	21.50 (4.74)	21.00 (4.67)	21.25	15.50 (4.04)	6.25 (2.69)	10.88	17.00	-
C.D. @ 5%		N.S.	0.38	0.301		0.315	0.375		0.352	0.254			
C.V.		10.113	7.28	5.914		6.401	8.036		7.901	7.722			

Figures in the parentheses are square root transformed values. NS- Non significant, DAS- Days after spray

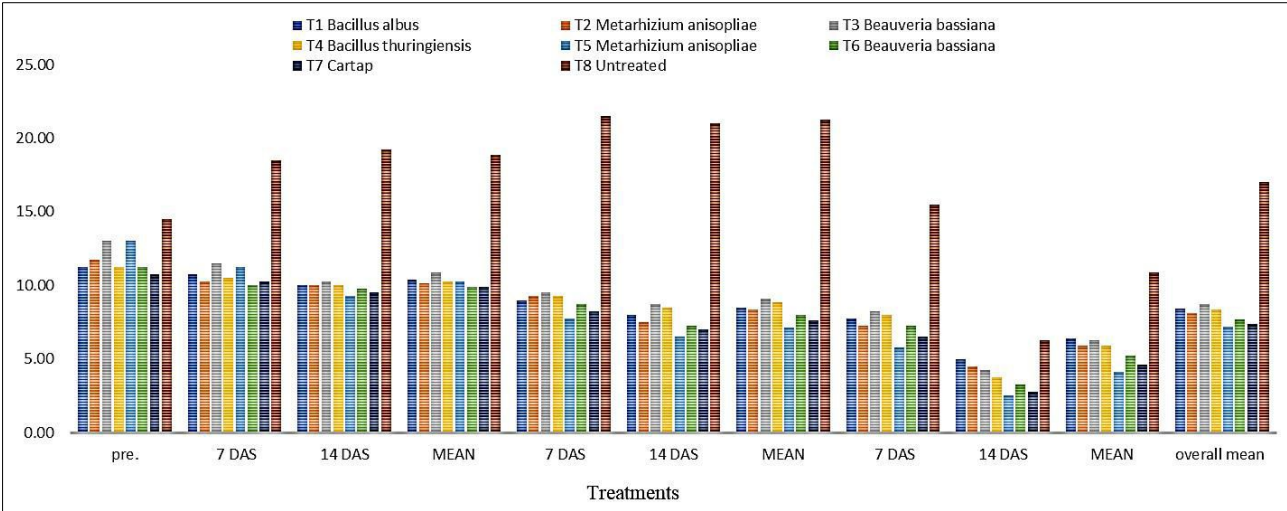


Fig 4: Effect of treatment application on the incidence of Brown plant hopper during *kharif*, 2024

Table 7: Effect of treatment application on the incidence of whorl maggot and rice hispa during *Kharif*, 2024

T no.	Treatment details	Dose (kg or l) /ha	Percent of whorl maggot leaf damage				Percent of rice hispa
			Pre-treatment	Post-treatment (1 st application)			Pre-treatment
				7 DAS	14 DAS	Mean	
T ₁	<i>Bacillus albus</i> NBAIR-BATP	5l /ha.	1.37 (6.65)	1.40 (6.74)	0	0.70	2.34 (8.69)
T ₂	<i>Metarhizium anisopliae</i> NBAIR-Ma35	5l /ha.	1.93 (7.76)	1.07 (5.93)	0	0.54	2.95 (9.77)
T ₃	<i>Beauveria bassiana</i> NBAIR-Bb5a	5l /ha.	1.62 (7.17)	1.07 (5.81)	0	0.54	2.79 (9.48)
T ₄	<i>Bacillus thuringiensis</i> NRRI-TB 261	1kg /ha.	2.07 (8.20)	1.06 (5.85)	0	0.53	2.63 (9.13)
T ₅	<i>Metarhizium anisopliae</i> NRRI-TF 9	1kg/ha.	2.12 (8.23)	1.29 (6.51)	0	0.65	2.02 (8.10)
T ₆	<i>Beauveria bassiana</i> NRRI- TF 6	1kg/ha.	1.92 (7.62)	1.33 (6.57)	0	0.66	2.67 (9.33)
T ₇	Cartap hydrochloride 4G	20kg/ha.	1.89 (7.77)	1.34 (6.62)	0	0.67	1.83 (7.46)
T ₈	Untreated	-	1.36 (6.61)	2.30 (8.71)	0	1.15	2.31 (8.62)
C.D. @ 5%			N.S.	1.08	N.S.		N.S.

Figures in parentheses are arcsine transformed values, NS- Non significant, DAS- Days after spray

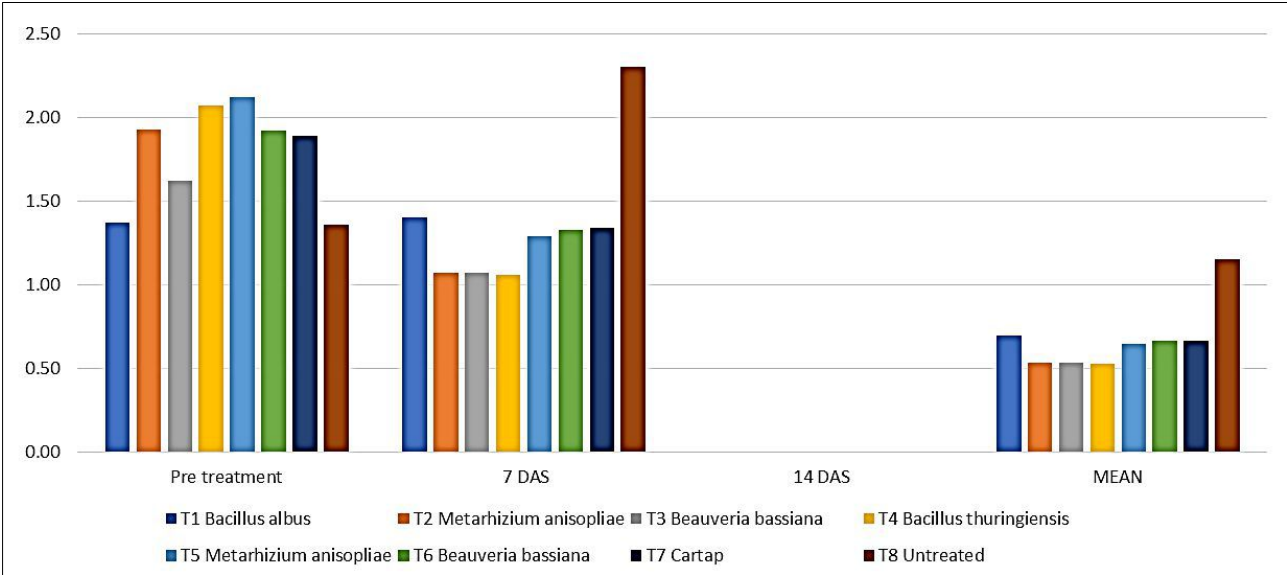


Fig 5: Effect of treatment application on the incidence of whorl maggot during *Kharif*, 2024

Summary

The field evaluation with three sprays at 50, 65, and 80 DAT using different biopesticides and one chemical insecticide, assessed at 7 and 14 DAS against yellow stem borer, leaf folder, BPH, whorl maggot and rice hispa. The observations revealed that (T₄) *Bacillus thuringiensis* applied @ 1 kg/ha was found as the most effective in reducing stem borer dead hearts and white ear heads. This was followed by (T₇) Cartap hydrochloride @ 20kg/ha

which were statistically on par in reducing both parameters. For controlling rice leaf folder, *Cnaphalocrocis medinalis* the lowest leaf damage was recorded in (T₄) *Bacillus thuringiensis* @ 1kg/ha treated plots followed by (T₅) *Metarhizium anisopliae* @ 1kg/ha which was at par with each other. In case of BPH, the lowest infestation was found in (T₅) *Metarhizium anisopliae* @ 1kg/ha treated plots which was followed by (T₇) Cartap hydrochloride @ 20 kg/ha. The highest infestation of BPH was found in the

untreated control plots. Whorl maggot and rice hispa incidences were low and statistically non-significant in pre-treatment, with (T₄) *Bacillus thuringiensis* giving minimum post-treatment incidence.

Conclusion

The study concluded that *Bacillus thuringiensis* @ 1 kg/ha (T₄) was most effective in reducing yellow stem borer and rice leaf folder, while *Metarhizium anisopliae* @ 1 kg/ha (T₅) showed the best control for brown planthopper (BPH). Cartap hydrochloride @ 20 kg/ha (T₇) also performed well against stem borer and BPH. *Bacillus thuringiensis* @ 1kg/ha (T₄) significantly reduced whorl maggot incidence after spraying, while rice hispa incidence remained low and statistically non-significant throughout the study.

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