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Lokesh Kumar Sen
M.Sc. Scholar, Department of Entomology, COA, Raipur, Chhattisgarh, India

Dr. Navneet Rana
Professor, Department of Entomology, College of agriculture and research station Kanpa, Mahasamund, Chhattisgarh, India

Dr. Richa Choudhary
Assistant Professor, Department of Entomology, College of Agriculture and Research Station Kanpa, Mahasamund, Chhattisgarh, India

Sushant Sharma
M.Sc. Scholar, Department of Entomology, COA, Raipur, Chhattisgarh, India

Corresponding Author:
Lokesh Kumar Sen
M.Sc. Scholar, Department of Entomology, COA, Raipur, Chhattisgarh, India

Investigation of the ability of botanical derivatives and microbial bio- pesticides to manage major insect pests in rice farming

Lokesh Kumar Sen, Navneet Rana, Richa Choudhary and Sushant Sharma

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Abstract
The bio-efficacy study of various plant derivatives and microbial insecticides showed that the lowest incidence of dead heart (4.52% per hill) and white ear heads (5.27% per hill) occurred in the NSKE treatment. Its performance was statistically comparable with the combinations of Karanja leaf extract-Neem oil-*Bacillus thuringiensis*, Neem leaf extract-Eucalyptus oil-*Beauveria bassiana*, Bitter gourd leaf extract-Neem oil-*Bacillus thuringiensis*, and *B. thuringiensis*-Karanja leaf extract-Neem oil. For rice leaffolder, the pooled mean of three sprays indicated that NSKE was the most effective treatment, recording only (3.91%) leaf damage, followed closely by Karanja leaf extract-Neem oil-*B. thuringiensis* (4.12%). In the case of rice butterfly larval incidence, the combination of Eucalyptus oil-*Beauveria bassiana*-Neem leaf extract was most effective (3.53%), followed by Neem leaf extract-Eucalyptus oil-*B. bassiana* (3.63%).

Keywords: *Bacillus thuringiensis*, *Beauveria bassiana*, Neem leaf extract, Karanja leaf extract, Bitter gourd leaf extract, Neem oil, NSKE, Eucalyptus oil

1. Introduction
Rice (*Oryza sativa* L.) belonging to the family Gramineae, tribe *Oryzae*, with chromosome number 24 i.e., 2n= 24 is the staple food crop for more than 60% of the world population and especially it is of much significance in countries of Southeast Asian region. Rice is the one and only cereal crop, which is grown in the condition of submerged water and it uses more amount of water than any other crop (Food and Agriculture Organization, 2004).

Botanical options are becoming popular compared to traditional pesticides. They target specific pests while being effective in small amounts. Plus, they break down quickly without leaving harmful residues behind in our food or environment. When we use botanical pesticides along with other methods to manage pests better they might lessen how much synthetic pesticide we need or help slow down resistance among pests (Khater, 2012) [7].

Bacillus thuringiensis (*Bt*), which currently holds about 2 per cent of the total insecticidal market. The most significant bacterial pathogens encompass subspecies or strains of *Bacillus thuringiensis*. Each of the strains has been proven to produce a unique mix of toxins and targets the death of one or several closely related species of insects (*Bt* subspecies *kurstaki* and *aizawai* for lepidopteran larvae) and (*Bt* subspecies *tenebrionis* for coleopteran larvae). Mycoinsecticides are developed successfully for entomopathogenic fungi, such as *Beauveria spp.*, *Metarhizium spp.*, *Lecanicillium spp*. and *Isaria spp.*

The field experiment on 'Management of major pests infesting rice (*Oryza sativa* L.) using botanicals 'was conducted during *Kharif* season of 2018 at Agronomy farm, College of Agriculture, Dapoli. Three sprays of botanicals were undertaken against yellow stem borer, blue beetle and leaf folder at 15 days intervel. The results for yellow stem borer revealed that the *Azadirachtin* 10000 ppm (1%) @ 3 ml/liter was found to be most effective which recorded (2.57%) dead hearts per hill compared to untreated control (8.87%). For leaf folder *Azadirachtin* 10000 ppm (1%) @ 3 ml/liter was found most effective treatment which recorded (5.35%) infested leaves per hill compared to untreated control (12.99%) (Bhojane *et al.*, 2020) [2].

2. Material and Methods

Table 1: Experimental Details

Parameter	Details
Crop	Paddy (*Oryza sativa* L.)
Variety	Swarna
Experimental Design	Randomized Block Design
Date of Sowing	13/07/2024
Date of Transplanting	01/08/2024
Number of Treatments	10
Number of Replications	3
Experimental Unit	770 m²
Spacing	20 cm × 15 cm
Plot Size	5 m × 4 m (20 m²)
Spraying Schedule	1st spray: 24/09/20242nd spray: 10/10/20243rd spray: 26/10/2024

An experimental area of 770 m2 was taken which was well ploughed and prepared as per the recommended agronomical practices. Swarna paddy variety was planted. Entire experimental area was divided in three replicated manners with a plot size of 5m×4m. Total ten treatments were planned. In each plot the observation for the insect pest were taken after emergence up to maturity of the crop at seven days interval.

Table 2: Treatment details of plant derivatives and microbial insecticides

Treatment	Name of the treatment	Dose/hectare	Dose/lit. of water
T_1	Karanja leaf Extract -Neem Oil- *Bacillus thuringiensis*	7.5 lit - 1lit- 1lit	15ml/lit -2ml/lit- 2ml/lit
T_2	Neem leaf Extract -Eucalyptus oil- *Beauveria bassiana*	7.5 lit - 1lit - 3.5lit	15ml/lit -2ml/lit- 7ml/lit
T_3	Bitter gourd leaf Extract -Neem Oil- *Bacillus thuringiensis*	7.5 lit-1lit-1lit	15ml/lit-2ml/lit-2ml/lit
T_4	Neem oil - *Bacillus thuringiensis*- Karanja leaf Extract	1lit- 1lit-7.5 lit	2ml/lit-2ml/lit-15ml/lit
T_5	Eucalyptus oil -*Beauveria bassiana*- Neem leaf Extract	1lit - 3.5lit-7.5 lit	2ml/lit-7ml/lit-15ml/lit
T_6	*Bacillus thuringiensis* - Karanja leaf Extract- Neem oil	1lit-7.5 lit - 1lit	2ml/lit-15ml/lit - 2ml/lit
T_7	*Beauveria bassiana* - Neem leaf Extract- Eucalyptus oil	3.5lit-7.5 lit - 1lit	7ml/lit-15ml/lit - 2ml/lit
T_8	NSKE - NSKE - NSKE	7.5lit - 7.5lit-7.5lit	15ml/lit - 15ml/lit-15ml/lit
T_9	Chlorantraniliprole-Chlorantraniliprole- Chlorantraniliprole	0.15lit - 0.15lit - 0.15lit	0.3ml/lit- 0.3ml/lit-0.3ml/lit
T_{10}	Untreated Control	-	-

An experimental area of 770 m2 was selected, and it well be ploughed and prepared as per the recommended agronomical practices. Swarna variety of rice was planted. Entire experimental area was divided in three replicated manners with a plot size of 5 m x 4 m. Total ten treatments was planned. In each plot the observation for the insect pests was taken after emergence up to maturity of the crop. A total of thirty (30) experimental plots each with 20 m2 areas (5 m × 4 m) was prepared. Each treatment was assigned randomly and independently to each experimental block with a row to row spacing 20 cm and plant to plant spacing 15 cm within plot. The observation was recorded in each plot on ten randomly selected hills of every replication for major insect pests of rice and natural enemies of pests was recorded carefully. Spraying of plant derivatives and microbial insecticides was carried out after pest infestation. Before each spraying observation of the insect pests was thoroughly taken known as pretreatment observation and post treatment observation was taken on 1, 3-, 7-, 10- and 15-days interval.

3. Results

Overall Relative efficacy of plant derivatives and microbial insecticides against dead heart incidence caused due to yellow stem borer

Overall mean of three spray indicates that Chlorantraniliprole gave best result for the management of dead heart incidence by yellow stem borer (3.85%/hill). Among plant derivatives and microbial insecticides least dead heart percent was observed in NSKE (4.52%).

Table 3: Overall Relative efficacy plant derivatives and microbial insecticides against dead heart incidence caused due to yellow stem borer.

Treatment	Treatment Details	Mean of 1st Spray	Mean of 2nd Spray	Mean of 3rd Spray	Overall Mean
T_1	Karanja leaf extract + Neem oil + *Bacillus thuringiensis*	6.65 (14.93)	5.91 (14.06)	3.18 (9.91)	5.24 (13.09)
T_2	Neem leaf extract + Eucalyptus oil + *Beauveria bassiana*	6.49 (14.87)	5.89 (14.02)	3.10 (9.82)	5.16 (12.97)
T_3	Bitter gourd leaf extract + Neem oil + *Bacillus thuringiensis*	5.91 (14.03)	6.55 (14.80)	3.98 (11.17)	5.48 (13.46)
T_4	Neem oil + *Bacillus thuringiensis* + Karanja leaf extract	7.33 (15.65)	7.05 (15.38)	4.63 (12.28)	6.33 (14.50)
T_5	Eucalyptus oil + *Beauveria bassiana* + Neem leaf extract	7.93 (16.33)	6.52 (14.75)	5.46 (13.40)	6.63 (14.88)
T_6	*Bacillus thuringiensis* + Karanja leaf extract + Neem oil	6.53 (14.74)	5.98 (14.12)	4.59 (12.13)	5.70 (13.77)
T_7	*Beauveria bassiana* + Neem leaf extract + Eucalyptus oil	6.33 (14.52)	6.43 (14.68)	4.15 (11.46)	5.63 (13.66)
T_8	NSKE + NSKE + NSKE	5.75 (13.82)	4.77 (12.58)	3.04 (9.57)	4.52 (12.71)
T_9	Chlorantraniliprole + Chlorantraniliprole + Chlorantraniliprole	-	4.64 (12.18)	4.00 (11.36)	2.92 (9.38)
T_{10}	Untreated Control	7.82 (16.23)	8.50 (16.93)	8.57 (17.02)	8.30 (16.73)

Figures in parentheses are angular transformed value

Overall Relative efficacy of plant derivatives and microbial insecticides against against white ear head incidence caused due to yellow stem borer Mean of white ear head incidence: Overall minimum white ear heads/plant (4.08) was observed in Chlorantraniliprole (T_9). Among plant derivatives and microbial insecticides least white ear heads percent was observed in NSKE (5.27%). which was statistically at par with T_1, T_2, T_3 and T_6 while it was significantly lower than any other treatments. All the treatments were statistically significantly differing as compared to Untreated control (8.37) in providing the lower number of white ear heads.

Table 4: Relative efficacy of plant derivatives and microbial insecticides against white ear head incidence caused due to yellow stem borer

Treatment	Treatment Details	Mean
T_1	Karanja leaf extract + Neem oil + *Bacillus thuringiensis*	5.37 (13.59)
T_2	Neem leaf extract + Eucalyptus oil + *Beauveria bassiana*	5.63 (13.71)
T_3	Bitter gourd leaf extract + Neem oil + *Bacillus thuringiensis*	5.63 (13.71)
T_4	Neem oil + *Bacillus thuringiensis* + Karanja leaf extract	5.89 (14.03)
T_5	Eucalyptus oil + *Beauveria bassiana* + Neem leaf extract	7.01 (15.37)
T_6	*Bacillus thuringiensis* + Karanja leaf extract + Neem oil	5.83 (13.96)
T_7	*Beauveria bassiana* + Neem leaf extract + Eucalyptus oil	5.87 (14.36)
T_8	NSKE + NSKE + NSKE	5.27 (13.49)
T_9	Chlorantraniliprole + Chlorantraniliprole + Chlorantraniliprole	4.08 (11.29)
T_{10}	Untreated Control	8.37 (16.87)
	SEm ±	0.19
	CD (0.05)	0.51

Figures in parentheses are angular transformed value

Overall Relative efficacy of plant derivatives and microbial insecticides against incidence of leaves damaged of the leaffolder; Overall mean of three spray indicates Chlorantraniliprole that gave best result in management of leaffolder (3.66%). Among plant derivatives and microbial insecticides least leaffolder infestation was observed in NSKE (3.91%).

Table 5: Overall Relative efficacy of plant derivatives and microbial insecticides against incidence of leaves damaged of the leaffolder.

Treatment	Treatment Details	Mean of 1st Spray	Mean of 2nd Spray	Mean of 3rd Spray	Overall Mean
T_1	Karanja leaf extract + Neem oil + *Bacillus thuringiensis*	4.79 (12.62)	3.88 (11.32)	3.71 (11.09)	4.12 (11.69)
T_2	Neem leaf extract + Eucalyptus oil + *Beauveria bassiana*	4.50 (12.24)	4.20 (11.77)	3.83 (11.25)	4.17 (11.78)
T_3	Bitter gourd leaf extract + Neem oil + *Bacillus thuringiensis*	4.00 (12.45)	4.17 (11.71)	3.93 (11.26)	4.10 (11.83)
T_4	Neem oil + *Bacillus thuringiensis* + Karanja leaf extract	4.94 (12.84)	3.90 (11.40)	3.00 (10.99)	4.10 (11.77)
T_5	Eucalyptus oil + *Beauveria bassiana* + Neem leaf extract	5.70 (12.98)	4.40 (11.85)	3.24 (11.24)	4.50 (12.04)
T_6	*Bacillus thuringiensis* + Karanja leaf extract + Neem oil	5.32 (13.32)	4.40 (12.07)	3.90 (11.46)	4.30 (12.30)
T_7	*Beauveria bassiana* + Neem leaf extract + Eucalyptus oil	5.01 (12.92)	4.42 (12.08)	4.05 (11.55)	4.49 (12.21)
T_8	NSKE + NSKE + NSKE	4.49 (12.20)	3.58 (11.32)	3.66 (11.00)	3.91 (9.20)
T_9	Chlorantraniliprole + Chlorantraniliprole + Chlorantraniliprole	4.45 (12.16)	3.21 (10.21)	3.34 (10.43)	3.66 (11.43)
T_{10}	Untreated Control	5.99 (14.16)	6.90 (15.27)	6.56 (14.82)	6.48 (14.73)

Figures in parentheses are angular transformed value

Overall Relative efficacy of plant derivatives and microbial insecticides against incidence of rice butterfly Overall mean of three spray indicates that Chlorantraniliprole gave best result in management of rice butterfly 2.75 larvae/hill by Eucalyptus oil -*Beauveria bassiana*- Neem leaf Extract 3.53 which was statistically at par with T_1 T_2, T_3, T_4, T_6, T_7 and T_8 except untreated control. Highest mean population of larvae were recorded in untreated control plot 5.35.

Table 6: Overall Relative efficacy plant derivatives and microbial insecticides against the incidence of rice butterfly

Treatment	Treatment Details	Mean of 1st Spray	Mean of 2nd Spray	Mean of 3rd Spray	Overall Mean
T_1	Karanja leaf extract + Neem oil + *Bacillus thuringiensis*	4.66 (2.37)	3.80 (2.21)	2.99 (1.99)	3.81 (2.18)
T_2	Neem leaf extract + Eucalyptus oil + *Beauveria bassiana*	3.70 (2.16)	3.98 (2.22)	3.23 (2.05)	3.63 (2.15)
T_3	Bitter gourd leaf extract + Neem oil + *Bacillus thuringiensis*	4.14 (2.24)	3.64 (2.15)	3.28 (2.05)	3.68 (2.16)
T_4	Neem oil + *Bacillus thuringiensis* + Karanja leaf extract	4.46 (2.33)	3.57 (2.13)	3.05 (2.00)	3.69 (2.16)
T_5	Eucalyptus oil + *Beauveria bassiana* + Neem leaf extract	3.45 (2.10)	3.81 (2.19)	3.35 (2.07)	3.53 (2.12)
T_6	*Bacillus thuringiensis* + Karanja leaf extract + Neem oil	4.22 (2.27)	3.65 (2.15)	3.32 (2.07)	3.73 (2.17)
T_7	*Beauveria bassiana* + Neem leaf extract + Eucalyptus oil	4.12 (2.25)	4.08 (2.24)	3.41 (2.09)	3.87 (2.20)
T_8	NSKE + NSKE + NSKE	4.00 (2.23)	3.81 (2.19)	3.48 (2.10)	3.76 (2.18)
T_9	Chlorantraniliprole + Chlorantraniliprole + Chlorantraniliprole	2.96 (1.46)	2.93 (1.25)	2.37 (1.16)	2.75 (1.19)
T_{10}	Untreated Control	5.83 (2.61)	5.35 (2.51)	4.89 (2.42)	5.35 (2.52)

Figures in parentheses are square root transformed value

4. Conclusion

The study demonstrated that plant derivatives and microbial insecticides are effective, eco-friendly alternatives for managing major insect pests of rice. Among all treatments, NSKE consistently performed best, recording the lowest incidence of dead heart, white ear heads, and leaffolder damage. Several combination treatments particularly those involving Neem oil, Karanja leaf extract, *Bacillus thuringiensis*, Eucalyptus oil, and *Beauveria bassiana* were statistically comparable and also provided effective pest suppression. For rice butterfly, the Eucalyptus oil-*Beauveria bassiana*-Neem leaf extract combination showed the highest efficacy. Overall, the results highlight the potential of integrating botanical extracts with microbial agents as a sustainable pest management strategy in rice cultivation, reducing dependency on synthetic insecticides and supporting environmentally safe crop protection.

5. Importance of This Research

This research is significant because it addresses the urgent need for eco-friendly pest management strategies in rice cultivation. Rice is a staple food for a large portion of the global population, and its productivity is severely constrained by major insect pests such as the yellow stem borer, leaffolder, and rice butterfly. Excessive reliance on synthetic insecticides has led to issues like pesticide resistance, environmental contamination, residue problems, and negative impacts on natural enemies. By evaluating the effectiveness of plant derivatives and microbial insecticides, this study provides sustainable alternatives that are safer for the environment, compatible with natural enemies, and suitable for integrated pest management (IPM) programs. The findings help farmers reduce chemical inputs, lower production costs, and promote long-term soil and ecosystem health. Additionally, the study contributes scientifically validated information that can guide future research, extension programs, and policy decisions toward adopting bio-rational pest management in rice ecosystems.

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