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Relative efficacy of some biorational and microbial insecticides against yellow stem borer and whorl maggot of *boro* paddy

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ABSTRACT

A field trial was conducted at Rice Research Station, Hooghly of West Bengal during *boro* season to evaluate the effect of some biorational and microbial insecticides against rice insect-pests. Insecticides of different origins such as, *Beauveria bassiana* Balsamo-Crivelli, *Bacillus thuringiensis* Berliner, *Metarhizium anisopliae* Metchnikoff, spinosad, azadirechtin, and cartap hydrochloride as check, have been tested in different combinations against yellow stem borer (*Scirpophaga incertulas* Walker) and whorl maggot (*Hydrellia* spp. Robineau-Desvoidy). The lowest whorl maggot infestation was recorded in spinosad treated plots (1.84%) followed by *B. thuringiensis* var. *kurstaki* (2.58%) and azadirachtin treatment (2.59%). The lowest yellow stem borer infestation as dead heart was recorded in plots treated with spinosad (2.92%) followed by *M. anisopliae* (3.32%) followed by azadirachtin (3.44%). The white ear head damage was recorded lowest in spinosad (8.04%) followed by *B. bassiana* + *B. thuringiensis* var. *kurstaki* (9.25%) and *M. anisopliae* treatment (9.48%). The highest grain yield and straw yield of *boro* rice were obtained from the plots treated with spinosad (57.72 q ha^{-1} grain yield and 6958 kg ha^{-1} straw yield) followed by *B. bassiana* + *B. thuringiensis* var. *kurstaki* (54.31 q ha^{-1} grain yield and 6681 kg ha^{-1} straw yield) followed by *B. bassiana* + *M. anisopliae* (53.47 q ha^{-1} grain yield and 64.58 q ha^{-1} straw yield).The overall results revealed spinosad as the most effective insecticide against both the insect species whorl maggot and yellow stem borer, showing minimum white ear head and dead heart with higher grain and straw yield.

Key words: *Beauveria bassiana, Bacillus thuringiensis*, *Metarhizium anisopliae,* Spinosad, *Scirpophaga incertulas*, *Hydrellia* spp

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INTRODUCTION

In terms of the area planted with rice and its production, India ranks second globally. However, due to the lack of inbuilt resistance to various biotic stresses, as discernible in about 1,000 rice cultivars across the country, the yield capacity is dented (Chatterjee *et al*., 2020). In India, the state West Bengal ranks second in area and first in rice production (Anonymous, 2019). A critical analysis of the difference between the nation's potential and actual rice yields will show that many variables act as constraints on yield. Among these factors, insect-pests significantly lead to the loss of rice production as well as productivity (Bajya *et al*., 2010; Chatterjee *et al*., 2016). The insect yellow stem borer (YSB), *Scirpophaga incertulas* of rice is distributed widely, covering almost all the Asian countries. YSB usually comprised more than 90% of the borer populations and damage the rice crop from seedling to maturity causing “Dead heart” at tillering stage and “White ear head” at the reproductive stage (Chatterjee *et al*., 2017). Rice yellow stem borer, *S. incertulas* is the country's most dominant and damaging insect-pest that causes yield losses ranging from 10 to 60 per cent (Chatterjee and Mondal, 2014; Chatterjee *et al*., 2015). Rice yellow stem borer is the notable insects of West Bengal as they are the one of main constrain in rice production during *boro* season. The status of this insect was predicted for future periods in India (Vennila *et al.*, 2019). Rice whorl maggot, *Hydrellia philippina* Ferino begins to infest the rice plant at transplanting and feeds on the central whorl leaf of the vegetative stage of the rice plant (Chatterjee *et al.*, 2019) which may affect yield production of rice.

The inappropriate and indiscriminate use of chemical insecticides has a significant negative impact on the agro-ecosystem, human health, and wildlife. The synthetic chemical insecticides may affect human health as well as cause environmental hazards. Therefore, biorational and microbial insecticides maybe considered economic, time saving and feasible management practice. *Boro* rice in West Bengal is known for high productivity of rice but may cause high infestations of dead heart and white ear head by yellow stem borer. According to Gangopadhyay and Chatterjee (2020) the dead heart infestation during *boro* season was varied from 11.51 to 21.82% dead heart and 6.90 to 26.40% white ear damage. Hence, in this experiment the authors have applied different microbial insecticides as tank mix having selective toxicity with different modes of action to control the whorl maggot and borer insects of rice.

MATERIALS AND METHODS

Experimental site and Treatment details

The field experiment was conducted on the rice variety *Satabdi* (IET 4786a high yielding early duration rice variety, popularly known as "*Minikit*" to the farming community of West Bengal) in *boro* season during 2011-12 (December-April) at Rice Research Station, Chinsurah, Hooghly, West Bengal, located at 88°24' E longitude and 22°52' N latitude with an altitude of 8.62 m AMSL in the alluvial zone of West Bengal. The crop variety, *Satabdi* was sown in the raised beds @ 50 g seeds m^2 during 2nd week of December. There has been no seed treatment with any pesticides. The seed bed preparation and planting method was carried out by maintaining a row to row and plant to plant distance of 20 cm and 15 cm, respectively, 40 days of old seedlings were transplanted in the main field.

The insecticides of microbial origin, *Beauveria bassiana, Bacillus thuringiensis* var. *kurstaki, Metarhizium anisopliae*; their combination as tank mix, *B. bassiana* + *B. thuringiensis* var. *kurstaki, B. bassiana* + *M. anisopliae, B. thuringiensis* var. *kurstaki* + *M. anisopliae*, spinosad 45% SC normal, azadirachtin 10000 ppm, as well as cartap hydrochloride 50% SP normal (insecticidal check) along with untreated control check (water spray) were applied at 30 and 50 days after transplanting (DAT). The details of the treatments are depicted in Table 1.

Observations and data collection

The insect-pest infestation was determined based on dead heart (DH) or white ear head (WE) by yellow stem borer (YSB) and damaged/folded leaves by rice whorl maggot (WM) in all the experimental plots. Random observations on DH, WE for yellow stem borer and damaged/folded leaves for rice WM were taken from ten hills chosen from each plot starting from 30 DAT (before spray) onwards at 10 days interval.

Computation of per cent of DH, WE, and WM was done using the following formula proposed by Chatterjee and Mondal (2020).

Per cent DH = (Number of DH per hill /total No. of panicle bearing tillers per hill)*100

Per cent damaged leaves caused by WM = (Number of damaged leaves per hill /total No. of leaves per hill)*100

Per cent white ear head = (Number of WE per hill /total No. of panicle bearing tillers per hill)*100

All the per cent data were converted into angular transformed values before statistical analysis.

The number of natural enemies i.e. predators of rice pests *viz.* spiders (*Tetragnatha* sp., *Argiope* sp., *Oxyopes* sp., *Lycosa* sp., *Phidippus* sp.), rove beetle (*Paederus fuscipes*) and ground beetle (*Ophionea* sp.) were recorded randomly selected ten hills from each plot at 50 DAT.

The harvesting was done during second fortnight of April during both the seasons. The grain yield and straw yield were recorded from each plot leaving two border rows from each side and the plot yield was converted into q ha^{-1}.

Data analysis

The experimental data were subjected to analysis of variance (ANOVA) with the requisite transformation whenever needed using SPSS statistical tools before comparison of treatment means at probability p=0.05.

RESULTS AND DISCUSSION

The observations on DH%, WM%, WE%, natural enemy population, both grain and straw yield have been presented in Tables 2-5 respectively. Fig. 1 shows the decreased insect-pest incidence over control and increased grain yield over control.

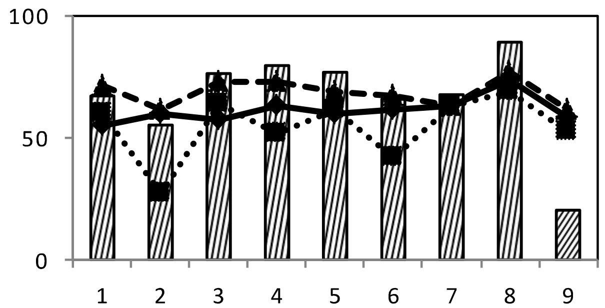

Fig.1. Comparison between decreased insect-pest incidence and increased grain yield over control

Insecticides on whorl maggot

The WM% was ranged from 2.29-2.96% and non-significant at 30 DAT. However, the lowest WM% was recorded in spinosad treated plots at 40 and 50 DAT followed by azadirachtin treatment (2.62%) at 40 DAT and *B. thuringiensis* var. *kurstaki* treatment at 50 DAT (Table 2). The pooled data indicated that the lowest WM% was recorded in spinosad treated plots followed by *B. thuringiensis* var. *kurstaki* treatment and azadirachtin treatment respectively (Table 2). The decrease of WM% over control was calculated highest in spinosad treatment (73.67%) followed by *B. thuringiensis* var. *kurstaki* treatment followed by azadirachtin treatment respectively (Fig. 1).

Against yellow stem bore

The yellow stem borer incidence, in terms of DH infestation was recorded at 30, 40, 50 DAT (Table 3). Thereafter, the pooled DH% at 40 and 50 DAT was calculated. The WE infestation was noticed and noted just before harvest. Before spray at 30 DAT the DH% was ranged from 4.39-4.97% and non-significant. The spinosad treatment showed the lowest DH% at 40 DAT and 50 DAT followed by *M. anisopliae* treatment at 40 DAT and azadirachtin treatment at 50 DAT respectively (Table 3). The pooled data indicated that the lowest DH% was revealed in spinosad treated plots followed by *M. anisopliae* treatment and azadirachtin treatment. This result corroborated with the results of Karthikeyan *et al.* (2008); Chatterjee and Mondal (2014); Madhu *et al.* (2020) who reported that spinosad 45 SC was the most effective among other treatments in reducing dead heart. Similar findings were observed by Choudhary *et al.* (2017); Madhu *et al.* (2020) who reported that neem oil was one of the best treatments against yellow stem borer. Sumathi and Ramasubramanian (2013) also reported that black bug population was significantly low in *M. anisopliae* and neem oil treated plots in paddy field. The decrease of DH% over control was found maximum in spinosad treatment (68.42%) followed by the treatment of *M. anisopliae* (64.08%) and azadirachtin treatment (62.85%) (Fig. 1).

The lowest white ear was recorded in spinosad treatment followed by *B. bassiana* + *B. thuringiensis* var. *kurstaki* treatment and *M. anisopliae* treatment (Table 3). Our findings were in corroboration with Karthikeyan *et al.* (2008); Chatterjee and Mondal (2014); Madhu *et al.* (2020). The decrease of WE% was recorded highest over the control in spinosad treatment (76.61%) followed by *B. bassiana* + *B. thuringiensis* var. *kurstaki* treatment and *M. anisopliae* treatment (Fig. 1).

Natural enemies

The natural enemy's *viz.* spider fauna (*Tetragnatha* sp., *Argiope* sp., *Oxyopes* sp., *Lycosa* sp. and *Phidippus* sp.), rove beetle *P. fuscipes*) and ground beetle (*Ophionea* sp.) were noticed at 50 DAT (Table 4). The spider population was ranged from 0.57-1.93 h^{-1} and the highest population was recorded in *B. bassiana* (1.93 h^{-1}) whereas, the lowest population of spider was recorded in cartap hydrochloride (0.57 h^{-1}).

Table 1. Treatment details of biorational and microbial insecticides along with their doses applied

Treatments	Insecticides	Type of bio-insecticides	Commercial name	Source of insecticides (Manufacturer/ marketing company)	Doses applied (g/ml per litre)
T_1	*Beauveria bassiana*	Microbial : fungus	*Bv* pure culture	Nodule Testing Laboratory (NTL), Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, India	1.5 g
T_2	*Bacillus thuringiensis* var. *kurstaki*	Microbial : bacteria	*Bt* pure culture	NTL, BCKV, Mohanpur, Nadia, India	1.5 g
T_3	*Metarhizium anisopliae*	Microbial : fungus	*Ma* pure culture	NTL, BCKV, Mohanpur, Nadia, India	2.0 g
T_4	*B. bassiana* + *B. thuringiensis* var. *kurstaki*	Microbial : fungus + bacteria	*Bv* + *Bt* pure culture	NTL, BCKV, Mohanpur, Nadia, India	(1.5 + 1.5) g
T_5	*B. bassiana* + *M. anisopliae*	Microbial : fungus + fungus	*Bv* + *Ma* pure culture	NTL, BCKV, Mohanpur, Nadia, India	(1.5 + 2.0) g
T_6	*B. thuringiensis* var. *kurstaki* + *M. anisopliae*	Microbial : bacteria + fungus	*Bt* + *Ma* pure culture	NTL, BCKV, Mohanpur, Nadia, India	(1.5 + 2.0) g
T_7	Spinosad 45% SC	Soil bacteria : *Saccharopolyspora spinosa*	Tracer	Agro Sciences India Pvt. Ltd.	0.3 ml
T_8	Azadirachtin 10000 ppm	Botanical : neem	Neemazal	E.I.D. Parry (India) Ltd.Dow	1.0 ml
T_9	Cartap hydrochloride 50% SP (insecticidal check)	Chemical insecticide	Padan	Coromondol Argico (P) Ltd.	1.0 g
T_{10}	Untreated control check	-	-	-	Water spray

Table 2. Efficacy of different biorational and microbial insecticides on whorl maggot (WM) of rice

Treatments	WM% at 30 DAT (before spray)	WM% at 40 DAT (10 days after 1st spray)	WM% at 50 DAT (20 days after 1st spray)	Pooled WM% (40 & 50 DAT)
T_1	2.26	3.37	3.00	3.18
T_2	2.45	3.02	2.61	2.82
T_3	2.71	3.13	2.90	3.01
T_4	2.29	3.03	2.13	2.58
T_5	2.65	3.02	2.59	2.81
T_6	2.72	3.06	2.37	2.71
T_7	2.31	1.97	1.71	1.84
T_8	2.96	2.62	2.55	2.59
T_9	2.90	2.89	3.01	2.95
T_{10}	2.60	7.33	6.66	7.00
$p<0.05$	NS	2.00	1.99	1.25
SEm (±)	0.37	0.67	0.66	0.44
CV	6.95	11.21	11.88	10.72

Table 3. Efficacy of different biorational and microbial insecticides on yellow stem borer of rice

Treatments	DH% at 30 DAT (before spray)	DH% at 40 DAT (10 days after 1st spray)	DH% at 50 DAT (20 days after 1st spray)	Pooled DH% (40 & 50 DAT)	WE% at pre-harvest
T_1	4.73 (12.56)	2.91(9.82)	4.55	3.73	10.04
T_2	4.65 (12.45)	5.94 (14.10)	7.64 (16.04)	6.79 (15.10)	13.17
T_3	4.56 (12.33)	2.30 (8.72)	4.34 (12.02)	3.32 (10.49)	9.48
T_4	4.59 (12.37)	3.29 (10.45)	5.62 (13.71)	4.46 (12.19)	9.25
T_5	4.68 (12.49)	2.68 (9.42)	4.41 (12.12)	3.54 (10.84)	10.67
T_6	4.48 (12.21)	4.39 (12.09)	6.34 (14.58)	5.36 (13.38)	11.38
T_7	4.97 (12.88)	2.07 (8.27)	3.77 (11.19)	2.92 (9.84)	8.04
T_8	4.39	2.88 (9.77)	3.99 (11.52)	3.44 (10.68)	12.72 (20.89)
T_9	4.55	4.18 (11.79)	4.66 (12.46)	4.42 (12.13)	13.22 (21.31)
T_{10}	4.86	7.21 (15.57)	11.28 (19.62)	9.25 (17.70)	34.37 (35.88)
$p<0.05$	N.S.	2.81	2.81	1.80	3.63
SEm (±)	0.72	0.94	0.94	0.63	1.21
CV	10.04	14.90	12.04	12.66	10.10

The figures in the parentheses are angular transformed values.

The population of rove beetle (0.20-0.67 h^{-1}) and ground beetle (0.23-0.63h^{1}) was non-significant. However, in all the cases, the insecticidal check cartap hydrochloride treatment resulted lowest population of predators of rice.

Plant yield

The highest grain yield and straw yield were obtained from spinosad treatment (57.72 q ha^{-1} grain yield and 69.58 q ha^{-1}straw yield) (Table 5). The second best grain yield and straw yield were recorded from *B. bassiana* + *B. thuringiensis* var. *kurstaki* treatment (54.31 q ha^{-1} grain yield and 66.81 q ha^{-1} straw yield) followed by *B. bassiana* + *M. anisopliae* treatment (53.47 q ha^{-1} grain yield and 64.58 q ha^{-1} straw yield).The findings of this experiment corroborate the results of Karthikeyan *et al.* (2008); Chatterjee and Mondal (2014) who reported that spinosad treated plots recorded the highest yield of rice by reducing insect-pests.

Table 4. Effect of different biorational and microbial insecticides on population of spider fauna, rove beetle and ground beetle

Treatments	**Spider No. hill^{-1}**	**Rove beetle No. hill^{-1}**	**Ground beetle No. hill^{-1}**
T_1	1.93	0.57	0.63
T_2	1.90	0.67	0.57
T_3	1.87	0.50	0.60
T_4	1.87	0.60	0.63
T_5	1.90	0.60	0.53
T_6	1.90	0.57	0.57
T_7	1.47	0.37	0.43
T_8	1.63	0.53	0.53
T_9	0.57	0.20	0.23
T_{10}	1.90	0.63	0.60
$p<0.05$	0.32	NS	NS
SEm (±)	0.11	0.12	0.10
CV	11.04	40.57	30.77

The highest increase of grain yield over control was discernible in spinosad treatment plots (88.99%) followed by *B. bassiana* + *B. thuringiensis* var. *kurstaki* treatment (79.36%) followed by *B. bassiana* + *M. anisopliae* treatment (76.61%) (Fig.1).This results of yield were similar with Reddy *et al.* (2013) who recorded the highest grain yield in application of *B. bassiana* followed by *M. anisopliae*.

Table 5. Effect of different biorational and microbial insecticides on grain and straw yield of rice

Treatments	**Grain yield (qha^{-1})**	**Straw yield (q ha^{-1})**
T_1	50.56	61.25
T_2	46.94	56.81
T_3	53.33	63.89
T_4	54.31	66.81
T_5	53.47	64.58
T_6	50.14	61.11
T_7	57.22	69.58
T_8	50.69	63.06
T_9	36.39	60.00
T_{10}	30.28	53.06
$p<0.05$	157.31	253.96
SEm (±)	52.54	84.82
CV	1.88	2.37

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