



Comparative efficacies of modules against major insect pests and natural enemies in rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted at regional Research and Technology Transfer Station (OUAT), Chiplima, Sambalpur, Odisha, during rainy season (*kharif*) 2019–20 to determine the comparative efficacies of various insecticides and botanicals modules against major insect pests and natural enemies of rice (*Oryza sativa* L.). There were 9 modules and overall data revealed that the all the treated plots recorded significantly lower per cent of dead heart; white ear-head caused by stem borer; silver shoot caused by gall midge; leaf folder infested leaves and plant hoppers. Among them, module consists of fipronil 5 sc @1500 ml/ha at 25–30 DAT, rynaxypyr 20 sc @150 ml/ha at 45–50 DAT and triflumezopyrim 106 sc @240 ml/ha at 65–70 DAT treated plot recorded significantly higher per cent reduction of stem borer infestation, leaf folder, plant hoppers and produced higher grain yield than the other modules as well as highest benefit cost ratio B:C (1.89) and next best was carbosulfan 25 EC @875 ml/ha, rynaxypyr 20 sc @150 ml/ha and flonicamid 50 WG @150 g/ha containing module. So, the module containing fipronil, rynaxypyr and triflumezopyrim may be adopted for the effective management of major insect pests of rice and helps the farmers from unwanted spraying of insecticides many times.

Keywords: Economic analysis, Insecticide modules, Leaf folder, Natural enemies, Plant hoppers, Stem borer

Rice (*Oryza sativa* L.) is one of the important cereal crops and more than 65% of the world population depends on it and in Indian condition it is one of the important staple foods for more than two third of the population (Joshi *et al.* 2018). More than 90% of the world's rice is grown and consumed in Asia. But, its production is affected by the infestation of many insect pests. Almost 300 species of insect pests attack the rice crop at different growth stages and within those, only 23 species cause notable damage. Among them, yellow stem borer (YSB) [*Scirpophaga incertulas* (Walk.)]; rice gall midge (GM) [*Orseolia oryzae* (Wood-Mason)]; leaf folder [*Cnaphalocrocis medinalis* (Guenee)]; brown plant hopper (BPH) [*Nilaparvata lugens* (Stal)] are the major reason for huge economic crop losses of rice. The YSB attacks the crop at all the stages of growth period and produces dead hearts and white heads like symptoms at vegetative and heading stage respectively. Plant hoppers suck the sap from the plant resulting in chlorosis, wilting and drying up of rice plant (Seni 2021). Gall midge produces silvery-white, tubular leaf gall known as *silver shoot* or *onion shoot* which causes the tiller sterile and does not

bear panicle. The leaf folder caterpillars fold the leaves and scrape the green tissues of the leaves and causes scorching like appearance and later leaf drying (Upadhyay *et al.* 1975).

Chemical insecticides are still reliable method to suppress the major insect pests in the rice crop. It is observed that although many conventional insecticides are used to manage rice insect pests, yet, most of the chemicals have failed to provide adequate control. So, new molecules are being added for their evaluation with an aim to have least effect on environment. For this, the present study was carried out to find the efficacy of certain insecticide modules against major insect pests and natural enemies of rice.

MATERIALS AND METHODS

An experiment was conducted at the experimental farm of Regional Research and Technology Transfer Station (OUAT), Chiplima, Sambalpur, Odisha, during rainy (*kharif*) season 2019–20 in Randomized Block Design (RBD), having 9 treatments which were replicated thrice in a net experimental area of 5 m × 4 m each. Nursery of rice variety MTU-7029 (Swarna) was sown in the July and transplanting was done after 25 days of sowing at 20 cm × 15 cm hill spacing. All the agronomic practices were followed during crop growth period. The modules consisting of different chemicals and spray schedule are given in Table 1. Observations on the incidence of YSB produced

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Table 1 Treatment and spray schedules

Module	25–30 DAT*	45–50 DAT	65–70 DAT
T ₁	Neemazal 1 EC @1000 ml	Eucalyptus oil @1000 ml	Cartap hydrochloride 50 WP @1000 g
T ₂	Neemazal 1 EC @2 ml	Neemoil @5000 ml	Triflumezopyrim 10 SC @240 ml
T ₃	Neemazal 1 EC @1000 ml	Eucalyptus oil @1000 ml	Neem oil @5000 ml
T ₄	Chlorantraniliprole 0.4 G @10 kg	Cartap hydrochloride 50 WP @1000 g	Triflumezopyrim 10 SC @240 ml
T ₅	Neemoil @5000 ml	Fipronil 5 SC @1500 ml	Flonicamid 50 WG @150 g
T ₆	Fipronil 5 SC @1500 ml	Rynaxypyr 20 SC @150 ml	Triflumezopyrim 10 SC @240 ml
T ₇	Carbosulfan 25 EC @875 ml	Rynaxypyr 20 SC @150 ml	Flonicamid 50 WG @150 g
T ₈	Carbofuran 3 G @30 kg	Fipronil 5 SC @1500 ml	Flonicamid 50 WG @150 g
T ₉	Untreated Control		

*DAT, Days after transplanting.

dead heart/white ear head (DH/WEH), GM produced silver shoot (SS), plant hoppers number per hill were taken on 10 randomly selected hills per plot from each replication at 10 days after each spray. Whereas, leaf folder damage leaves (LFDL) were taken on 10 randomly selected hills per plot from each replication at 10 days after first and second spray. The white ear head (WEH) data was taken on 10 randomly selected hills from each plot just before harvest. Then percentage of dead hearts/white ears/silver shoot/leaf folder damage leaves were worked out as:

$$\text{DH or WEH (\%)} = \frac{\text{Number of dead hearts or white ear heads}}{\text{Total number of tillers observed in 10 hills}} \times 100$$

$$\text{SS (\%)} = \frac{\text{Number of silver shoots}}{\text{Total number of tillers observed in 10 hills}} \times 100$$

$$\text{LFDL (\%)} = \frac{\text{Total number of damaged leaves (one third or more of the leaf area is damaged)}}{\text{Total number of leaves observed in 10 hills}} \times 100$$

The hopper population per 10 hills was recorded 10 days after third spray. Among natural enemies, spider and mirid bug population per 10 hills were recorded at 10 days after third spray. Wherever necessary, the mean value of data obtained from field experiments were transformed and analyzed statistically by ANOVA. Finally, the grain yield was recorded on plot basis and expressed in tonnes per hectare. For economic analysis, numbers of chemical sprays, cost of cultivation (per ha), yield (t/ha), net returns (per ha) and benefit: cost ratio (B:C) were computed and analyzed.

RESULTS AND DISCUSSION

Stem borer: The results showed that all the tested modules were significantly effective in reducing the formation of dead hearts and white ear heads as compared to the untreated control (Table 2). In treated plots, yellow stem borer infestation recorded as dead hearts ranged from 1.02–4.27% and white ears ranged from 0.41–4.17% as

against 7.62 and 7.87% in untreated control respectively. Lower incidence of dead heart and white ear head caused by stem borer were noticed in fipronil 5 SC and rynaxypyr 20 SC containing module (1.02% DH and 0.41% WEH) and followed by carbofuran 3 G and rynaxypyr 20 SC containing module (2.57% DH and 1.58% WEH) and others. The modules 4, 5, 7 and 8 were significantly at par to each other's in stem borer management in rice ecosystem.

Gall midge: Data (Table 2) revealed that among different modules, carbofuran 3 G and fipronil 5 SC containing module was recorded to be significantly superior (74% reduction over control) in efficacy against gall midge than other modules. Next best module was fipronil 5 SC and rynaxypyr 20 SC containing module (64% reduction over control). Module 2 containing neemazal and Neem oil, module 5 containing neem oil and fipronil and module 7 containing carbosulfan were at par with each other in gall midge management. In the treated plots, the gall midge infestation recorded as silver shoot ranged from 6.73–15.33% as against 26.32% in control. All the botanicals containing modules reduced gall midge infestation moderately (12.14–15.33% SS).

Plant Hoppers: Data (Table 2) revealed that all the insecticide modules were significantly effective in reducing the infestation of rice plant hoppers. Among different insecticide modules, modules containing triflumezopyrim 10 SC @240 ml/ha (19.83–25.50 per 10 hills) was more effective than other treatments. Likewise, module containing fipronil 5 SC and flonicamid 50 WG was also effective against plant hoppers. All the modules were superior in efficacy for plant hoppers management (19.83–52 per 10 hills) and differed significantly from untreated control plot (75.67 per 10 hills).

Leaf folder: Data (Table 2) revealed that among different modules, rynaxypyr 20 SC containing modules were significantly more effective against leaf folder than other modules. It was also observed that all the tested modules were effective against leaf folder. In the treated plots, the leaf folder infestation was ranged from 0.25–2.88% as against 5.09% in control. All the botanical containing modules reduced the leaf folder infestation moderately (2.18–2.88%).

Table 2 Effect of insecticide/botanical modules against stem borer (DH% and WEH%), gall midge (SS%), leaf folder (LFDL%), BPH, mirid bugs, spiders (numbers/10 hills each) and on benefit cost ratio for major insect pests management in rice

Module	Mean data of 2019 and 2020*								Ex** (₹/ha)	INC ^s (₹/ha)	B:C
	DH%	WEH%	SS%	LFDL%	BPH	Mirid bugs	Spiders	Yield			
T ₁	3.58 (2.02)	2.80 (1.81)	15.33 (3.98)	2.26 (1.66)	52.00	32.2	11.8	4.36	50950	84584	1.66
T ₂	4.27 (2.18)	3.94 (2.11)	12.14 (3.55)	2.88 (1.84)	25.50	13.8	7.7	4.37	54250	84778	1.56
T ₃	4.26 (2.18)	4.17 (2.16)	14.55 (3.88)	2.18 (1.63)	46.17	35.8	15.7	4.10	53300	79540	1.49
T ₄	2.26 (1.66)	2.02 (1.58)	17.71 (4.26)	0.81 (1.14)	24.50	10.2	4.8	4.95	52300	96030	1.84
T ₅	2.97 (1.86)	2.13 (1.62)	12.26 (3.57)	1.67 (1.47)	21.17	8.7	6.8	4.57	51510	88658	1.72
T ₆	1.02 (1.23)	0.41 (0.94)	9.37 (3.14)	0.25 (0.86)	21.14	9.0	5.7	5.12	52650	99328	1.89
T ₇	2.45 (1.72)	1.70 (1.47)	12.27 (3.57)	1.26 (1.33)	24.17	14.5	5.0	4.83	50010	93702	1.87
T ₈	2.57 (1.75)	1.58 (1.44)	6.73 (2.69)	0.99 (1.22)	19.83	6.7	3.5	4.91	52110	95254	1.83
T ₉	7.62 (2.85)	7.87 (2.89)	26.32 (5.18)	5.09 (2.36)	75.67	43.0	18.7	3.29	45000	63826	1.42
S.Em±	0.07	0.09	0.08	0.03	1.51	0.98	0.55	0.09			
CD (P=0.05)	(0.20)	(0.26)	(0.25)	(0.08)	(4.52)	(2.94)	(1.65)	(0.26)			

*Figures in parentheses are square root transformed values; Ex: Expenditure, \$: Income; **Average labourer charge ₹300/day, Neemazal 1 EC @ ₹1000/litre, Eucalyptus oil @ ₹2800/litre, Neem oil @ ₹600/litre, Cartap hydrochloride 50 WP @ 650/kg, Carbosulfan 25 EC @ 1360/litre, Chlorantraniliprole 0.4 G @ 230/kg, Fipronil 5 SC @ ₹1000/litre, Triflumezopyrim 10 SC @ ₹3750/240 ml, Rynaxypyr 20 SC @ ₹1800/150 ml, Carbofuran 3 G @ ₹120/kg. **Rice MSP ₹1940/q.

Natural enemies: The results on the presence of spiders in different insecticide modules (Table 2) showed that highest number of spiders were found in the untreated control (18.7/10 hills) than the other insecticide module treated plots. Among different treatments it was found that maximum spider population was present in modules with botanicals (7.7–15.7/10 hills) whereas, only insecticide treated plots had less in numbers (3.5–6.8/10 hills) at 75 days after transplanting. Similarly, green mirid bug, another important predator of the rice plant hoppers was more in numbers in the untreated control (43/10 hills) than the other treated plots. Among different insecticide modules it was observed that low population of mirid bugs was present in insecticide treated plots whereas high population of the mirid bugs were noticed in botanical treated plots (32.2–35.8/10 hills).

Yield: It was found that (Table 2), module 6 (fipronil 5 SC @1500 ml/ha, rynaxypyr 20 SC @150 ml/ha and triflumezopyrim 10 SC @240 ml/ha) treated plot recorded highest grain yield of 5.12 t/ha followed by module 4 (chlorantraniliprole 0.4 G @10 kg/ha, cartap hydrochloride 50 WP @1000 g/ha and triflumezopyrim 10 SC @240 ml/ha) and yield was 4.95 t/ha. It is also observed that module 4, 6 and 8 were significantly at par with each other in terms of production of rice crop. All the modules gave superior yield (4.10–5.12 t/ha) than untreated control plot (3.29 t/ha).

Economic analysis: It is found that modules 6 containing fipronil 5 SC, rynaxypyr 20 SC and triflumezopyrim 10 SC had highest benefit cost (B:C) ratio (1.89) than other modules whereas modules containing botanicals had less benefit cost ratio due to their higher market price although they were less harmful to the natural enemies (Table 2).

It is evident that module containing fipronil, rynaxypyr and triflumezopyrim had low infestation of stem borer, leaf folder, gall midge and BPH and could prove highly effective against major insect pests of rice. Kumar *et al.* (2011) reported among different tested molecules, fipronil was found very effective against rice gall midge. Similarly, Seni and Pal (2021) observed comparatively less in numbers of silver shoot in fipronil treated plot than other chemical treated rice plots. Fipronil belongs to phenyl pyrazole group which acts through blocking GABAA-gated chloride channels in the central nervous system and disruption of the GABAA receptors, prevents the uptake of chloride ions resulting in excess neuronal stimulation and death of the insect (Ratra and Casida 2001). Chaudhari *et al.* (2017) reported that the rynaxypyr was highly effective against stem borer and leaf folder in rice. In another study, Seni and Naik (2017) documented that percent infestation in terms of dead heart and white ear head was significantly low in rynaxypyr treated plots compared to other treatments. Similarly, Pal *et al.* (2018) also reported the better efficacy of

rynaxypyr 20 sc against leaf folder. Rynaxypyr comes under chlorantraniliprole insecticides and belongs to anthranilic diamide group which interfere insects' ryanodine receptors (Lahm *et al.* 2007). Beside this, due to its green level category rynaxypyr is less harmful to environment and users as well as natural enemies (Kadam *et al.* 2005 and Seni *et al.* 2019). Regarding management of plant hoppers in rice, Seni *et al.* (2019) reported the better efficacy of triflumezopyrim 10 sc against them. Triflumezopyrim, belongs to the novel class of mesoionic insecticides (IRAC Group 4) and it acts on insect by binding to the orthosteric site of the nicotinic acetylcholine receptor (nAChR) (Cordova *et al.* 2016).

So, the selection of right insecticides with different mode of action at a right time (application of tipronil 5 sc @1500 ml/ha at 25–30 days after transplanting followed by spraying of rynaxypyr 20 sc @150 ml/ha at 45–50 days after transplanting and triflumezopyrim 10 sc @240 ml/ha at 65–70 days after transplanting) will help the farmers from unwanted spraying of insecticides many times. Moreover, the insecticides are also safe to predators. It is always advocated to spray chemicals according to economic threshold level (ETL) of the insect pest. But main difficulties of the ETL based pest management in rice ecosystem are the measurement of ETL for particular insect pest which is mainly based on numerical data (Sogawa *et al.* 1979) and selection of pesticides in consideration of single pest threshold level is less applicable to check the crop damage since the pests occur at multiple threshold combination (Foster and Mourato 2000). For this, farming communities are reluctant to spray molecules according to ETL level of the insect pests in rice ecosystem. Thus, the above-mentioned module may be adopted as prophylactic measure for the effective management of major insect pests of rice where they are appeared seriously year after year. Whereas botanical containing modules may be used in organic rice cultivation as well as where insect pest's infestation is moderate or may be in rotation with other chemicals.

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