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Field efficacy of triflumezopyrim 5% + spinetoram 9% against yellow stem borer and brown plant hopper in rice ecosystem and their effects on natural enemies

SD Mohapatra, Swoyam Singh and GS Giri

Abstract
A field trial was conducted at experimental farm of ICAR-NRRI, Cuttack during *kharif* 2019 and *rabi* 2020 to evaluate the bio-efficacy of triflumezopyrim 5% + spinetoram 9% (14% SC) against yellow stem borer and brown plant hopper in rice and their effect on natural enemies. The experiment was comprising of seven treatments *viz.*, T_1 Triflumezopyrim 5% + spinetoram 9% (14% SC), T_2 Triflumezopyrim 5% + spinetoram 9% (14% SC) T_3 Triflumezopyrim 5% + spinetoram 9% (14% SC) T_4 Triflumezopyrim 10.6% SC T_5 Spinetoram 12% SC T_6 Fipronil 5% SC T_7 Untreated Control. The Lowest BPH population was recorded in triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai/ha which are statistically at par with triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g ai/ha throughout the observation. Similarly, lowest white ear head (WEH) was recorded in triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai/ha. Triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g a.i/ha provided effective control of yellow stem borer and brown plant hopper. Further, triflumezopyrim 5% + spinetoram 9% (14% SC) was found to be safe to the predatory mirid bug, *Cyrtorhinus lividipennis* and spider, *Pardosa pseudoannulata* in rice ecosystem.

Keywords: Bio-efficacy, triflumezopyrim, spinetoram, yellow stem borer, brown plant hopper, rice

Introduction
Rice (*Oryza sativa* L) is the staple food of South and South-East Asian people and provides more than 50% of the calories consumed in this region. Insect pests are the major biotic constraints in the production of the rice throughout the region. About 800 species of insects are known to attack rice crop right from showing till consumption as reported by Mohapatra *et al* (2008) [1]; Mohapatra *et al* (2021) [2]. Among the insect pests, yellow stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), brown plant hopper (*Nilaparvata lugens*), white backed plant hopper (*Sogatella furcifera*), swarming caterpillar (*Spodoptera mauritia*), gundhi bug (*Leptocorisa* sp.) and green leaf hopper (*Nephotettix* sp.) are known to cause significant damage to the rice crop resulting in severe loss in grain yields reported by Mohapatra *et al* (2019) [3]. In national levels, stem borer accounted 30%, planthoppers 20%, gall midge 15%, leaf folder 10% and other pests 25% losses in rice reported by Krishnaiah and Varma (2013) [4]. Among the various strategies adopted to manage these notorious pests, insecticides are the first line of defense. Most of the carbamate and organophosphate group of insecticides used on agricultural crops are banned or in limited use due to their deleterious effect on human health and environment. To tackle this crisis, recently several newer insecticide molecules possessing advanced mode of action against insect pests have been developed and shown noticeable results in controlling the pest population. Because of the selection pressure due to indiscriminate use of insecticides, the outbreak of insects, insecticide resistance in pest arose. Pesticides with single active principle are likely to induce the development of resistance in insects. Triflumezopyrim (TFM), the recently developed insecticide is a new class of insecticides categorized as mesoionics reported by Cordova *et al* (2016) [5], Baehaki *et al* (2017) [6] whereas spinetoram is an insecticidal mixture of two active neurotoxic constituents of *Saccharopolyspora spinosa*. Combination of triflumezopyrim 5% + spinetoram 9% with different mode of action are unlikely lead to pesticide resistance. In this view, the present study was envisaged to determine the effective field dose of triflumezopyrim 5% + spinetoram 9% against yellow stem borer and brown plant hopper in rice.

Material and Methods

The present experiment was conducted at research farm of ICAR-National Rice Research Institute, Cuttack during *kharif* 2019 and *rabi* 2020 (20^0 N and 86^0E with 24m above MSL) to study the bio-efficacy of triflumezopyrim 5% + spinetoram 9% (14% SC) against yellow stem borer (YSB) and brown plant hopper (BPH) in rice. Rice cultivar TN 1 used in the experiment because of susceptibility to target insects and were sown in nursery. 22-days old seedlings were transplanted in plot size of 4 x 5 m^2 with a spacing of 20 x 15 cm. Recommended package of practices for raising paddy in the nursery and main field were followed. Nitrogenous fertilizer was applied in three split doses. Crop management as per standard practice including the control of non-target insect pests and diseases though foliar sprays of pesticides were adopted.

After pre-treatment count, when the insect pest population reached above economic threshold level (ETL), the spray solutions of different doses of insecticides were prepared as per treatment schedule (Table 1). The spraying was undertaken in the morning hours through battery operated knapsack sprayer. The quantity of water taken as 500 liters per hectare. After 15 days of first spray, the second spray was undertaken.

Table 1: Treatment details

S. No.	Treatments	Dose (g ai/ha)	Product ml/ha	Product ml/plot
1	Triflumezopyrim 5% + spinetoram 9% (14% SC)	56 (20+36)	400	0.8
2	Triflumezopyrim 5% + spinetoram 9% (14% SC)	70 (25+45)	500	1.0
3	Triflumezopyrim 5% + spinetoram 9% (14% SC)	84 (30+54)	600	1.2
4	Triflumezopyrim 10.6% SC	25	235.8	0.47
5	Spinetoram 12% SC	45	375	0.75
6	Fipronil 5% SC	75	1500	3.0
7	Untreated Control	-	-	-

Observation (*i*) *Brown plant hopper:* At random 20 hills per plot selected and number of BPH per hill were counted at 0, 3, 7, 10 and 14 days after imposition of treatments (ii) *Yellow stem borer:* Similarly, randomly 20 hills/plot were selected and number of white ear head per hill at 100% flowering, milking and panicle ripening stage were recorded (iii) *Yield*: Rice grain yield of each treatment was also recorded and the same was converted to yield/ha (iv) *Natural enemies:* The numbers of natural enemies like mirid bug, *Cyrtorhinus lividipennis* and wolf spider, *Pardosa pseudoannulata* on 20 randomly selected hills were recorded at each observation date and presented as average number hill. Data recorded on pest and natural enemies' population and grain yields from the experiment were transformed and analyzed to draw a meaningful conclusion as suggested by Gomez and Gomez (1984) [7]

Results and Discussion

Brown plant hopper: Insecticides were tested under field condition on the basis of number of BPH per hill, changes in the population of natural enemies and finally the yield. It is clear from the result (Table 2 and 3) that the BPH population had reached the economic threshold level (ETL) before the application of insecticides and the population did not vary significantly among the plots earmarked for treatment imposition. At 3 days after first spray, the triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai /ha recorded lowest number of BPH per hill (1.1 and 1.3 in both the seasons) followed by triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g ai/ha (1.6 and 1.9 BPH per hill). However, the BPH population between these two treatments didn't differ significantly. Upto 15 days after first spray, triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 and 84 g ai/ha maintained the population of BPH below economic threshold level (ETL) as against untreated control (14.5 and 27.2 per hill after 1st spray in both the seasons). Same trend was noticed after 2nd spray also. Population of BPH considerably reduced after 3 days of spraying and continued even after 7 days. Lowest population was recorded in triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g and 84 g ai/ha which are statistically at par throughout the observation in both the seasons. In all, triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai/ha were recorded as the best treatments over other doses of triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g ai/ha and triflumezopyrim 5% + spinetoram 9% (14% SC) @ 56g ai/ha and triflumezopyrim 10.6% SC, spinetoram 12% SC and fipronil 5% SC. Present results on higher efficacy of triflumezopyrim 5% + spinetoram 9% (14% SC) against BPH can be corroborated with the findings of Dash *et al*. [8] who reported that neem oil in combination with either monocrotophos or chloropyriphos performed significantly better in controlling WBPH compared with its application alone at 3 per cent concentration. The present findings are also in agreement with the previous reports of novel chemical molecules triflumezopyrim by Guruprasad *et al* (2016) [9], cyzypyr by Venkatreddy *et al* (2012) [10] in suppressing the planthopper population.

Yellow stem borer: The results depicted in Table 4 on percent white ear head (WEH) due to yellow stem borer infestation in rice revealed that the infestation level was above economic threshold level (ETL) in flowering, milking and ripening stages in untreated control which was significantly higher than all the treatments in both the seasons. However, WEH counts were maintained below economic threshold level (ETL) in flowering (2.8, 3.1%), milking (1.9, 2.2%) and ripening (2.5, 3.1%) stage in the triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai /ha % treatment on rice crop in both the seasons. In terms of YSB incidence, triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai/ha was recorded as the best treatment over other doses such as triflumezopyrim 5% + spinetoram 9% (14% SC) @70g ai/ha, triflumezopyrim 5% + spinetoram 9% (14% SC) @56 g ai/ha and triflumezopyrim 10.6% SC, spinetoram 12%SC and fipronil 5%SC. The present results are also in conformity with the findings of Guruprasad *et al* (2016) [9], Liao *et al* (2021) [11] and Jalgaonkar *et al* (2022) [12]

Natural enemy: Population of natural enemies was found to be moderate in both seasons. Mirid bug and wolf spider were more abundant. Population of mirid bug was found to be highly dependent on the availability of brown plant hopper for

preying. It is evident from the Table 5 that after 15 days of first insecticidal treatment mean number of mirid bug per hill was comparatively low in all insecticide treated plots than the untreated control. The predatory mirid bug population recorded at 3 and 14 days after insecticide application indicated significant variation among the treatments. Although, there was significant difference in natural enemies among treatments after 3 DAT during *kharif* 2019, no significant difference was observed during *rabi* 2020. With regard to spider population, there was significant difference among the population after 3 DAT during *rabi* 2020 and after14 DAT during *kharif* 2019. Moreover, there was no significant difference in mirid bug and spider population between triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g ai/ha and triflumezopyrim 5% + Spinetoram 9% (14% SC) @ 84 g ai/ha treatment over the years.

Marketable yield: The two years pooled data of marketable grain yield of rice (Table 7) revealed that among all the treatments, triflumezopyrim 5% + spinetoram 9% (14% SC) @ 84 g ai/ha recorded highest grain yield (4.35 t/ha) and was on par with triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g ai/ha (4.12 t/ ha) which is significantly superior over untreated control (3.06 t/ ha). Guruprasad *et al* (2016) [9] reported that triflumezopyrim @ 35 and 25 g a.i/ha were superior over other treatments and control which registered significantly higher yield of 7.60 and 7.31 ton per hectare, respectively.

Table 2: Efficacy of triflumezopyrim 5% + spinetoram 9% against brown plant hopper (BPH) in paddy during *kharif 2019*

Tr No	Treatments	Dose (g ai/ha)	Product g or ml/ha	BPH/hill							
				DBT	1st Spray				2nd Spray			
					3 DAT	7 DAT	10 DAT	14 DAT	3 DAT	7 DAT	10 DAT	14 DAT
T_1	Triflumezopyrim5% + Spinetoram 9% (14% SC)	56 (20+36)	400	10.2 (3.20)	3.8 (1.96)	1.3 (1.16)	1.9 (1.40)	2.3 (1.53)	3.2 (1.81)	1.1 (1.07)	1.6 (1.29)	2.0 (1.42)
T_2	Triflumezopyrim5% + Spinetoram 9% (14% SC)	70 (25+45)	500	9.5 (3.09)	1.6 (1.28)	0.3 (0.59)	0.7 (0.87)	1.1 (1.07)	1.4 (1.19)	0.3 (0.55)	0.6 (0.80)	0.9 (0.99)
T_3	Triflumezopyrim5% + Spinetoram 9% (14%) SC	84 (30+54)	600	9.3 (3.06)	1.1 (1.07)	0.2 (0.50)	0.5 (0.74)	0.9 (0.97)	0.9 (0.99)	0.2 (0.47)	0.4 (0.69)	0.8 (0.90)
T_4	Triflumezopyrim 10.6% SC	25	235.8	9.7 (3.12)	3.4 (1.86)	0.8 (0.92)	1.1 (1.07)	1.6 (1.28)	2.9 (1.71)	0.7 (0.85)	0.9 (0.99)	1.4 (1.19)
T_5	Spinetoram 12% SC	45	250	10.1 (3.19)	5.2 (2.29)	4.6 (2.16)	3.7 (1.94)	4.2 (2.06)	4.4 (2.11)	3.9 (1.99)	3.1 (1.79)	3.6 (1.90)
T_6	Fipronil 5%SC	75	1500	9.6 (3.11)	7.3 (2.71)	5.1 (2.27)	5.8 (2.42)	6.2 (2.50)	6.2 (2.50)	4.3 (2.09)	4.9 (2.23)	5.3 (2.31)
T_7	Untreated Check	-	-	9.4 (3.07)	10.1 (3.19)	12.4 (3.53)	13.8 (3.72)	14.5 (3.81)	8.6 (2.94)	10.5 (3.25)	11.7 (3.43)	12.3 (3.52)
	CD @ 5%			NS	0.382	0.453	0.489	0.422	0.398	0.475	0.492	0.462

Data in parentheses are √(x+0.5) transformed values; , NS-Non significant; DBT: Days before treatment; DAT: Days after Treatment

Table 3: Efficacy of triflumezopyrim 5% + spinetoram 9% against brown plant hopper (BPH) in paddy during *rabi 2020*

Tr No	Treatments	Dose (g ai/ha)	Product g or ml/ha	BPH/hill							
				DBT	1st Spray				2nd Spray			
					3DAT	7DAT	10DAT	14DAT	3DAT	7DAT	10DAT	14DAT
T_1	Triflumezopyrim5% + Spinetoram 9% (14%SC)	56 (20+36)	400	18.6 (4.32)	3.5 (1.88)	3.2 (1.80)	5.1 (2.27)	6.7 (2.60)	3.0 (1.74)	2.7 (1.66)	3.8 (1.96)	4.1 (2.04)
T_2	Triflumezopyrim5% + Spinetoram 9% (14% SC)	70 (25+45)	500	18.9 (4.35)	1.9 (1.40)	0.7 (0.87)	1.3 (1.16)	3.2 (1.80)	1.6 (1.29)	0.6 (0.80)	1.1 (1.07)	2.1 (1.47)
T_3	Triflumezopyrim5% + Spinetoram 9% (14%) SC	84 (30+54)	600	19.2 (4.39)	1.3 (1.16)	0.4 (0.67)	0.9 (0.97)	2.5 (1.60)	1.1 (1.07)	0.3 (0.62)	0.8 (0.90)	1.3 (1.16)
T_4	Triflumezopyrim 10.6% SC	25	235.8	18.6 (4.32)	3.2 (1.80)	1.9 (1.40)	2.8 (1.69)	3.8 (1.96)	2.7 (1.66)	1.6 (1.29)	2.4 (1.56)	2.7 (1.66)
T_5	Spinetoram 12% SC	45	250	18.4 (4.30)	5.4 (2.33)	3.2 (1.80)	4.6 (2.16)	5.5 (2.36)	4.6 (2.15)	2.7 (1.66)	3.9 (1.99)	4.5 (2.13)
T_6	Fipronil 5%SC	75	1500	18.7 (4.33)	7.1 (2.67)	4.2 (2.06)	5.6 (2.38)	6.3 (2.52)	4.4 (2.11)	3.5 (1.88)	4.3 (2.09)	4.8 (2.20)
T_7	Untreated Check	-	-	18.5 (4.31)	21.2 (4.61)	23.6 (4.86)	24.8 (4.98)	27.2 (5.22)	24.2 (4.92)	18.7 (4.33)	15.5 (3.94)	13.2 (3.64)
	CD @ 5%			NS	0.402	0.486	0.523	0.371	0.412	0.514	0.455	0.502

Data in parentheses are √(x+0.5) transformed values; NS-Non significant; DBT: Days before treatment; DAT: Days after Treatment

Table 4: Efficacy of triflumezopyrim 5% + spinetoram 9% against yellow stem borer in paddy during *kharif* 2019 & *rabi* 2020

Tr No	Treatments	Dose (g ai/ha)	Product g or ml/ha	White ear head (%)					
				kharif 2019			*rabi* 2020		
				Flowering	Milking	Ripening	Flowering	Milking	Ripening
T_1	Triflumezopyrim 5% + Spinetoram 9% (14%SC)	56(20+36)	400	2.8 (9.63)	3.7 (11.09)	4.8 (12.66)	3.1 (10.14)	3.7 (11.09)	4.5 (12.25)
T_2	Triflumezopyrim5% + Spinetoram 9% (14% SC)	70(25+45)	500	1.6 (7.27)	2.3 (8.72)	2.7 (9.46)	2.4 (8.91)	2.6 (9.28)	2.8 (9.63)
T_3	Triflumezopyrim5% + Spinetoram 9% (14%) SC	84(30+54)	600	1.3 (6.55)	1.9 (7.92)	2.5 (9.10)	2.2 (8.53)	2.8 (9.63)	3.1 (10.14)
T_4	Triflumezopyrim 10.6% SC	25	235.8	1.7 (7.49)	2.6 (9.28)	3.2 (10.30)	3.8 (11.24)	4.5 (12.25)	4.9 (12.79)
T_5	Spinetoram 12% SC	45	250	2.3 (8.72)	3.4 (10.63)	4.1 (11.68)	3.2 (10.30)	4.1 (11.68)	3.7 (11.09)
T_6	Fipronil 5%SC	75	1500	4.8 (12.66)	5.4 (13.44)	6.2 (14.42)	6.3 (14.54)	6.6 (14.89)	7.9 (16.32)
T_7	Untreated Check	-	-	8.3 (16.74)	10.2 (18.63)	11.4 (19.73)	11.3 (20.70)	12.5 (20.70)	13.6 (21.64)
	CD @ 5%			NS	1.354	1.276	1.522	1.684	1.432

Table 5: Effect of triflumezopyrim 5% + spinetoram 9% against Natural Enemy in paddy during *kharif* 2019 and *rabi* 2020

Tr No	Treatment	Dose (g a.i/ha)	Product g or ml/ha	No. of natural enemies/ hill											
				DBT (2019)		*kharif 2019*				DBT (2020)		*rabi 2020*			
						3 DAT		14 DAT				3 DAT		14 DAT	
				Mirid bug	Spider	Mirid bug	Spider	Mirid bug	Spider	Mirid bug	Spider	Mirid bug	Spider	Mirid bug	Spider
T_1	Triflumezopyrim5% + Spinetoram 9% (14%SC)	56 (20+36)	400	2.2 (1.50)	4.5 (2.13)	1.8 (1.36)	2.5 (1.60)	2.1 (1.47)	3.5 (1.88)	2.0 (1.42)	3.1 (1.77)	1.6 (1.29)	3.4 (1.85)	1.8 (1.35)	3.9 (1.97)
T_2	Triflumezopyrim5% + Spinetoram 9% (14% SC)	70 (25+45)	500	2.6 (1.63)	3.8 (1.96)	1.5 (1.24)	2.2 (1.50)	1.8 (1.36)	3.4 (1.86)	1.8 (1.35)	3.4 (1.85)	1.5 (1.26)	3.2 (1.80)	2.0 (1.42)	3.7 (1.94)
T_3	Triflumezopyrim5% + Spinetoram 9% (14%) SC	84 (30+54)	600	2.1 (1.47)	4.0 (2.01)	1.3 (1.16)	1.6 (1.28)	1.5 (1.24)	3.0 (1.75)	1.7 (1.32)	3.5 (1.87)	1.1 (1.08)	3.1 (1.76)	1.8 (1.37)	3.6 (1.90)
T_4	Triflumezopyrim 10.6% SC	25	235.8	1.9 (1.40)	3.7 (1.94)	2.3 (1.53)	2.1 (1.47)	1.9 (1.40)	3.3 (1.83)	1.8 (1.35)	3.7 (1.92)	1.7 (1.31)	3.0 (1.73)	1.8 (1.37)	3.6 (1.92)
T_5	Spinetoram 12% SC	45	250	2.4 (1.57)	4.3 (2.09)	1.9 (1.40)	3.5 (1.88)	2.2 (1.50)	3.7 (1.94)	2.0 (1.42)	3.4 (1.85)	1.8 (1.35)	2.9 (1.71)	1.6 (1.30)	4.0 (2.00)
T_6	Fipronil 5%SC	75	1500	2.0 (1.43)	3.1 (1.77)	1.7 (1.32)	2.7 (1.66)	1.5 (1.24)	3.2 (1.80)	1.9 (1.38)	3.0 (1.73)	1.3 (1.16)	2.5 (1.59)	1.5 (1.25)	3.1 (1.77)
T_7	Untreated Check	-	-	2.2 (1.50)	3.7 (1.94)	2.5 (1.60)	3.8 (1.96)	2.9 (1.72)	4.3 (2.09)	2.1 (1.46)	3.6 (1.90)	1.9 (1.39)	3.7 (1.92)	2.1 (1.46)	4.1 (2.04)
	CD @ 5%			NS	NS	0.183	NS	NS	0.152	NS	NS	NS	0.136	NS	NS

Data in parentheses are √(x+0.5) transformed values; NS-Non significant; DBT: Days before treatment; DAT: Days after Treatment

Table 6: Impact of triflumezopyrim 5% + spinetoram 9% on yield of paddy during *kharif* 2019 and *rabi* 2020

Tr No	Treatment	Dose (g a.i/ha)	Product g or ml/ha	Yield (t/ha)		
				Kharif 2019	Rabi 2020	Mean
T_1	Triflumezopyrim5% + Spinetoram 9% (14%SC)	56(20+36)	400	3.47	4.02	3.75
T_2	Triflumezopyrim5% + Spinetoram 9% (14% SC)	70(25+45)	500	3.78	4.46	4.12
T_3	Triflumezopyrim5% + Spinetoram 9% (14%) SC	84(30+54)	600	4.08	4.62	4.35
T_4	Triflumezopyrim 10.6% SC	25	235.8	3.36	3.86	3.61
T_5	Spinetoram 12% SC	45	250	3.47	3.73	3.60
T_6	Fipronil 5%SC	75	1500	3.42	3.62	3.52
T_7	Untreated Check	-	-	2.96	3.16	3.06
	CD @ 5%			0.41	0.38	0.32

Conclusion

The present investigation on bio-efficacy of triflumezopyrim 5% + spinetoram 9% (14% SC) conducted during *kharif*, 2019 and *rabi* 2020 showed that triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g a.i/ha provided effective control of yellow stem borer and brown plant hopper. Further, triflumezopyrim 5% + spinetoram 9% (14% SC) was safe to the predatory mirid bug, *Cyrtorhinus lividipennis* and spider, *Pardosa pseudoannulata* and showed no observable phytotoxicity to paddy even at the highest dosage. Hence, triflumezopyrim 5% + spinetoram 9% (14% SC) @ 70 g *a.i.*/ha may be recommended to manage yellow stem borer and brown plant hopper in rice.

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