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Field efficacy of new pre-mix formulation of Flonicamid 15% + Fipronil 15% WG against major insect pests of Rice

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Abstract
Field experiments were conducted to test the field efficacy of new insecticide molecule, a pre-mix formulation, Flonicamid 15% + Fipronil 15% WG against major insect pests of rice during *kharif* and *rabi* seasons of 2014-15 at experimental farm, ICAR-National Institute of Biotic Stress Management, Raipur. Flonicamid 15% + Fipronil 15% WG @ 150 g a.i ha^{-1} was the best treatment with lowest stem borer damage (% dead hearts and % white ears), leaf folder damage (% damaged leaves) and lowest incidence of brown planthopper and green leafhopper incidence (number hill^{-1}) followed by Flonicamid 15% + Fipronil 15% WG @ 120 g a.i ha^{-1} during both *kharif* and *rabi* seasons of 2014-15. Maximum grain yield of 5.2 and 5.4 t ha^{-1}(52.04 and 54.12 qha^{-1}) obtained in Flonicamid 15% + Fipronil 15% WG @ 150 g a.i ha^{-1} with highest benefit cost ratio of 2.42 and 2.52, respectively during *kharif* and *rabi* 2014-15. All the doses of Flonicamid 15% + Fipronil 15% WG were found safer to mirid bugs and spiders in rice ecosystem during the experiments. Flonicamid 15% + Fipronil 15% WG was found superior in controlling both lepidopteran borers and hemipteran sucking pests in rice.

Keywords: Efficacy, Flonicamid, Fipronil, leaf folder, Stem borer

1. Introduction
"Rice is Life" describes the importance of rice in human diet. It is grown worldwide over an area of 153 million hectares with annual production of more than 600 million tonnes. In India, it is cultivated in an area of 44.80 million hectares with an annual production of 89.31 million tonnes and productivity over two tonnes of milled rice per hectare (CMIE). [4] Insect pests are the severe constraints to rice production throughout the world (Dale) [5] where more than 100 species of insect pests attack and damage rice (Pathak). [23] Among all the insect pests, yellow stem borer (YSB), brown planthopper (BPH), rice leaf folder (RLF) and green leafhopper (GLH) are the major ones causing 21 to 51 per cent yield losses to rice (Singh and Dhaliwal) [26].
Yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) (Lepidoptera: Crambidae), is the most predominant stem borer of rice throughout tropical South and Southeast Asia (Khan *et al*.). [13] Larval damage to tillers during the vegetative phase results in "dead hearts," whereas during the reproductive phase results in "white ears" or unfilled panicle grains (Srivastava *et al*.). [29] Muralidharan and Pasalu [19] worked out the yield losses due to YSB damage and reported that one per cent dead heart or white ear, or both phases of stem borer damage could result in 2.5 per cent, 4.0 per cent and 6.4 per cent yield loss, respectively. YSB is difficult to manage because of its feeding nature *i.e.* feeding inside the stem and for the successful control heavy application of insecticides are required (Pathak and Khan). [22]
The rice leaf folder, *Cnaphalocrocis medinalis* Guenee earlier considered as a minor pest of rice in many Asian countries, appears to have become increasingly important with the spread of high yielding rice varieties and accompanying changes in cultural practices. Murugesan and Chelliah [20] reported that a 10 per cent increase in flag leaf damage by the leaf folder reduces grain yield by 0.13 g tillers^{-1} and the number of fully-filled grains by 4.5 per cent.
The brown planthopper (BPH), *Nilaparvata lugens* (Stål) and Green leafhopper (GLH), *Nephotettix virescens* are the most serious sucking pests of rice. BPH damages the plants by sucking the sap and transmitting virus diseases like grassy stunt, ragged stunt and wilted stunt. It causes economic damage by sucking phloem sap which in turn leads to hopper-burn and severe yield loss (AICRIP). [1] GLH also causes same type of damage and it transmits rice tungro virus disease. Large scale cultivation of high-yielding cultivars, application of high

level of nitrogenous fertilizers, continuous cropping, staggered planting and non-judicious use of insecticides have been reported for the increased outbreak of sucking pests (Chelliah and Heinriches). [3]

Although, the insecticide application is the first choice of farmers for the successful management of these pests, they need to apply more insecticides with different mode of action for the control of both borers and sucking pests. Hence, there is a need for insecticides with broad spectrum mode of action. With this background, an attempt was made to test efficacy of different doses of Flonicamid 15% + Fipronil 15% WG against major insect pests of rice.

2. Material and Methods

2.1 Experimental site

The field experiments were conducted at ICAR-National Institute of Biotic Stress Management, Baronda, Raipur, Chhattisgarh. The farm is located at an altitude of 281.8 m, latitude of 21° 22' 59.79'' N and longitude of 81° 49' 37.28'' E. The study area receives an annual average rainfall of 1150 mm.

2.2 Nursery raising and transplanting

Popular rice variety, Swarna (MTU-7029, medium stature with 145 days duration) is selected and sown in well prepared seed beds of size 10.0 m × 1.0 m. The nursery was raised as per standard package of practices without any plant protection measures. Twenty five days old seedlings were transplanted at the rate of 2 seedlings hill^{-1} in well prepared plots of 5 m × 5 m in main field. The rice crop was raised as per recommended package of practices suggested for the region except plant protection measures.

2.3 Field efficacy tests

Bio-efficacy of insecticides under field conditions were carried out during *kharif* and *rabi* seasons of 2014-15. The experiment was laid out in randomized block design with seven treatments and three replications. The treatments were; 1. Flonicamid 15% + Fipronil 15% WG @ 90 g a.i ha^{-1}; 2. Flonicamid 15% + Fipronil 15% WG @ 120 g a.i ha^{-1}; 3. Flonicamid 15% + Fipronil 15% WG @ 150 g a.i ha^{-1}; 4. Flonicamid 50% WG @ 75 g a.i ha^{-1}; 5. Fipronil 5% SC @ 75 g a.i ha^{-1}; 6. Thiamethoxam 25% WG @ 25 g a.i ha^{-1} and 7. Untreated control. All the treatments were applied using high volume knapsack sprayer fitted with hollow cone nozzle and spray solution was 375-500 l ha^{-1}. First spraying was done at 45 days after transplanting (DAT) and second spray was done at 60 DAT. The observations on stem borer damage was recorded as per cent dead hearts (DH) at one day before spray, 10 days after first spray and 10 days after second spray and per cent white ears (WE) at 15 days before harvest on 10 randomly selected hills. Leaf folder damage was recorded as per cent damaged leaves and total number leaves per 10 randomly selected hills. BPH and GLH were counted number per 10 randomly selected hills at one day before spray, 5, 10 and 15 days after spray. The calculations were made using following relations:

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

$$\% \text{ white ears} = \frac{\text{Number of white ears/hill}}{\text{Total number of panicle bearing tillers/ hill}} \times 100$$

$$\% \text{ damaged leaves} = \frac{\text{Number of leaves damaged/hill}}{\text{Total number of leaves per hill}} \times 100$$

Observations on impact of insecticides on natural enemies of rice ecosystem *viz*, *Cyrtorhinus lividipennis* and spider populations were also taken as number per 10 hills for *C. lividipennis* and number m^{-2} for spider populations.

2.4 Benefit: cost ratio

Economics of insecticide applications was computed on the basis of economic returns from grain and straw yields and cost of insecticidal treatments. Thus, B: C ratio was worked out for judging economics of insecticide treatments.

2.5 Statistical analysis

All the data was transformed with suitable transformation method before analysis (Gomez and Gomez). [7] The data pertaining to per cent dead hearts, per cent white ears, per cent leaf damage and incidence of BPH and GLH was analysed using General Linear Model (GLM) technique using SAS 9.2 (SAS) [25] statistical software package. The means were compared by Tukey's HSD test at P=0.05.

3. Results and Discussion

With respect to stem borer control, all the insecticide treatments were superior over untreated control during both seasons. Among insecticides, Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} was the best treatment with significantly lower per cent dead hearts at 10 days after first spray and 10 days after second spray during both *kharif* and *rabi* seasons of 2014-15. The next best treatment was Flonicamid 15% + Fipronil 15% WG @ 120 g a.i ha^{-1} however; it was at par with Fipronil 5% SC @ 75 g a.i. ha^{-1}. With respect to % white ear (WE), Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} recorded significantly lowest damage followed by Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1} both during *kharif* and *rabi* seasons of 2014-15 (Table 1). These finding were corroborated by the studies of Kartikeyan *et al*. [9] who reported the efficacy of one such combination product, Flubendiamide (4%) + Buprofezin (20%) @ 875 ml ha^{-1} against YSB. Similarly, Krishnamurthy *et al*. [16] also reported the efficacy of Buprofezin 20% + acephate 50% WP against YSB. Karthikeyan *et al*. [12] reported the efficacy of cartap hydrochloride in effective management of YSB and its impact on natural enemies. However, this is the first report on efficacy of Flonicamid 15% + Fipronil 15% WG against YSB in rice.

With respect to leaf folder control, all the insecticidal treatments were found effective over untreated control. Significantly lowest per cent damaged leaves were recorded in Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} both at 10 days after first spray and 10 days after second spray during *kharif* 2014-15 which was found at par with Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1}. Fipronil 5% SC @ 75 g a.i. ha^{-1} was found next best treatment along with Flonicamid 15% + Fipronil 15% WG @ 90 g a.i. ha^{-1} (Table 2). The similar results were observed during *rabi* season of 2014-15 (Table 2). These findings were corroborated by the findings of Krishnaiah *et al*. [14]; Jena [8]; Karthikeyan *et al*. [10-12]; Krishnamoorthy *et al*. [15, 16] and Srinivasan *et al*. [28] who tested various combination of chemicals for the control of leaf folder. Mahal *et al*. [18] reported that Fipronil 80 WG significantly reduced the leaf folder damage in basmati rice.

BPH incidence was significantly low in all the insecticide treated plots compared to untreated control plots. Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} was the superior treatment with lowest incidence of BPH at 5, 10 and 15 days after first and second spray during *kharif* 2014-15. The next best treatment was Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1} with less incidence of BPH. The similar results were observed during *rabi* 2014-15. However, Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} and Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1} were statistically at par with each other at 15 days after second spray during both seasons (Table 3). These findings were in confirmation with many other researchers who were reported efficacy of new insecticides and new combinations like fipronil, imidacloprid, thiamethoxam, acephate, Buprofezin 20% + acephate 50% and acephate 95% SG (Sontakke and Dash [27]; Lakshmi *et al*. [17]; Panda *et al*. [21]; Vardhani and Rao [30]; Dash and Mukherjee [6]; Krishnamoorthy *et al*. [15, 16]

All the insecticidal treatments were given significant control of GLH over untreated control. However, Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} gave superior control over other treatments with lowest incidence of GLH at 5, 10 and 15 days after first and second spray during both seasons (Table 4). The next best treatment was Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1} followed by Flonicamid 50% WG @ 75 g a.i. ha^{-1}. These findings were in confirmation with the findings of Bethke *et al*. [2], who reported the efficacy of thiamethoxam in reducing the population of green leafhoppers.

Grain yield was maximum in the treatment Flonicamid 15% + Fipronil 15% WG @ 150 g a.i. ha^{-1} with a best B: C ratio of 2.72, which was significantly superior over all other treatments both during *kharif* 2014-15 (Table 5). Flonicamid 15% + Fipronil 15% WG @ 120 g a.i. ha^{-1} was the next best treatment with respect to grain yield and B: C ratio during *kharif* 2014-15. However, Flonicamid 15% + Fipronil 15% WG @ 90 g a.i. ha^{-1}, Flonicamid 50% WG @ 75 g a.i. ha^{-1} and Fipronil 5% SC @ 75 g a.i. ha^{-1} were found at par with respect to grain yield during *kharif* 2014-15. Results were similar during *rabi* season 2014-15 (Table 5).

All the doses of Flonicamid 15% + Fipronil 15% WG along with other insecticidal treatments were proved safest to natural enemies of rice ecosystem (Table 6). No significant differences were noticed with respect to number of spiders and *Cyrtorhinus lividipennis* across all the insecticidal treatments at one day before and 10 days after first and second sprays during both seasons (Table 6). Earlier report indicates a decrease in population of natural enemies following sprays of neo-nicotinoid compounds and acute contact and oral toxicity to the parasitoid *Anagrus nilaparvate* and other predators and parasitoids in laboratory studies (Prabakhar *et al*.) [24]

Table 1: Efficacy of insecticides against Yellow stem borer (YSB), *Scirpophaga incertulas* damage in Rice during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i. ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif* 2014-15				*Rabi* 2014-15			
			% Dead heart			% WE	% Dead heart			% WE
			1 DBS	10 Days After 1st Spray	10 Days After 2nd Spray	15 DBH	1 DBS	10 Days After 1st Spray	10 Days After 2nd Spray	15 DBH
Flonicamid 15% + Fipronil 15% WG	90	300	5.00a (2.35)	2.08bc (1.61)	3.25d (1.94)	3.16d (1.91)	6.50a (2.65)	2.35c (1.69)	2.90c (1.84)	3.25c (1.94)
Flonicamid 15% + Fipronil 15% WG	120	400	4.67a (2.27)	1.88b (1.54)	2.14b (1.62)	2.12b (1.62)	5.26a (2.40)	1.90b (1.55)	1.33b (1.35)	2.74b (1.80)
Flonicamid 15% + Fipronil 15% WG	150	500	5.12a (2.37)	1.64a (1.46)	1.88a (1.54)	1.85a (1.53)	5.32a (2.41)	1.25a (1.32)	1.00a (1.22)	2.25a (1.66)
Flonicamid 50% WG	75	150	5.22a (2.39)	8.82d (3.05)	8.86 (3.06)	6.86e (2.71)	6.25a (2.60)	9.72e (3.20)	9.56d (3.17)	6.5d (2.65)
Fipronil 5% SC	75	1500	4.98a (2.34)	1.93b (1.56)	2.54c (1.74)	2.38c (1.70)	5.58a (2.47)	2.65d (1.77)	2.90c (1.84)	2.5b (1.73)
Thiamethoxam 25% WG	25	100	4.86a (2.32)	10.33e (3.29)	10.16e (3.26)	7.34f (2.80)	6.54a (2.65)	10.10f (3.26)	9.32d (3.13)	6.75e (2.69)
Untreated control	----	-----	5.15a (2.38)	11.15f (3.41)	10.26e (3.28)	7.50g (2.83)	5.84a (2.52)	11.5g (3.46)	10.87e (3.37)	7.25f (2.78)
$F_{(2, 6)}$ value			1.02	32.15	26.23	48.65	1.11	78.15	65.48	55.26
P r>F value			0.594	<0.0001	<0.0001	<0.0001	0.613	<0.0001	<0.0001	<0.0001

Note: DBS- Day before spray; DAS- Days after spray; WE- White earhead; DBH- Days before harvest; NS- non significant
Figures in parentheses indicate √(x+0.5) transformed value

Table 2: Efficacy of insecticides against Leaf folder, *Cnaphalocrocis medinalis* damage in Rice during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i. ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif* 2014-15			*Rabi* 2014-15		
			% Damaged leaves			% Damaged leaves		
			1 DBS	10 Days After 1st Spray	10 Days After 2nd Spray	1 DBS	10 Days After 1st Spray	10 Days After 2nd Spray
Flonicamid 15% + Fipronil 15% WG	90	300	10.23a (3.28)	2.12b (1.62)	3.18d (1.92)	10.56a (3.33)	3.04b (1.88)	2.08c (1.61)
Flonicamid 15% + Fipronil 15% WG	120	400	10.14a (3.26)	1.35a (1.36)	2.00a (1.58)	10.21a (3.27)	2.44a (1.71)	1.65b (1.47)
Flonicamid 15% + Fipronil 15% WG	150	500	10.22a (3.27)	1.15a (1.28)	1.98a (1.57)	9.54a (3.17)	2.22a (1.65)	1.05a (1.24)
Flonicamid 50% WG	75	150	10.89a (3.37)	6.23d (2.59)	8.35d (2.97)	11.23a (3.42)	7.95c (2.91)	6.95d (2.73)
Fipronil 5% SC	75	1500	10.87a (3.37)	2.02b (1.59)	2.92c (1.85)	10.5a (3.32)	3.25b (1.94)	2.00c (1.58)
Thiamethoxam 25% WG	25	100	10.10a (3.26)	6.75c (2.69)	8.22d (2.95)	11.56a (3.47)	7.85c (2.89)	7.15e (2.77)
Untreated control	----	-----	10.38a (3.30)	7.15e (2.77)	8.15d (2.94)	10.55a (3.32)	8.45d (2.99)	8.14f (2.94)
$F_{(2, 6)}$ value			0.984	46.26	36.15	1.234	65.26	55.15
P r>F value			0.364	<0.0001	<0.0001	0.589	<0.0001	<0.0001

Note: DBS- Day before spray; DAS- Days after spray; NS- non significant
Figures in parentheses indicate √(x+0.5) transformed value

Table 3: Efficacy of insecticides against Brown plant hopper (BPH), *Nilaparvata lugens* in Rice during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i.ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif* 2014-15							*Rabi*-2014-15						
			No. of BPH hill^{-1}							No. of BPH hill^{-1}						
			1st Spray				2nd Spray			1st Spray				2nd Spray		
			1 DBS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	1 DBS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
Flonicamid 15% + Fipronil 15% WG	90	300	10.33a (3.29)	3.33c (1.96)	2.67c (1.78)	4.33c (2.20)	2.33d (1.68)	1.67d (1.47)	2.67c (1.78)	9.33a (3.14)	2.67b (1.78)	1.67c (1.47)	3.67c (2.04)	2.67c (1.78)	1.33c (1.35)	3.00c (1.87)
Flonicamid 15% + Fipronil 15% WG	120	400	10.00a (3.24)	2.67b (1.78)	1.33b (1.35)	3.00b (1.87)	1.00b (1.22)	0.67b (1.08)	1.00a (1.22)	10.67a (3.34)	2.33b (1.68)	1.33b (1.35)	3.33b (1.96)	1.33b (1.35)	0.67b (1.08)	1.00a (1.22)
Flonicamid 15% + Fipronil 15% WG	150	500	10.33a (3.29)	2.33a (1.68)	1.00a (1.22)	2.67a (1.78)	0.33a (0.91)	0.00a (0.71)	1.00a (1.22)	11.33a (3.44)	1.67a (1.47)	1.00a (1.22)	3.00a (1.87)	0.33a (0.91)	0.33a (0.91)	1.00a (1.22)
Flonicamid 50% WG	75	150	10.00a (3.24)	2.67b (1.78)	2.33c (1.68)	4.00d (2.12)	2.00c (1.58)	1.33c (1.35)	2.33b (1.68)	10.67a (3.34)	2.67b (1.78)	1.33b (1.35)	3.00a (1.87)	1.67b (1.47)	1.31c (1.35)	2.33b (1.68)
Fipronil 5% SC	75	1500	11.33a (3.44)	6.33e (2.61)	5.33e (2.41)	6.67f (2.68)	4.00f (2.12)	3.67f (2.04)	4.33e (2.20)	12.33a (3.58)	5.33d (2.41)	4.33e (2.20)	6.00e (2.55)	4.00e (2.12)	3.35d (1.96)	4.37e (2.20)
Thiamethoxam 25% WG	25	100	9.67a (3.19)	4.67d (2.27)	3.67d (2.04)	6.00e (2.55)	3.67e (2.04)	3.33e (1.96)	4.00d (2.12)	11.67a (3.49)	4.67c (2.27)	3.33d (1.96)	5.67d (2.48)	3.67d (2.04)	3.00d (1.87)	4.05d (2.12)
Untreated control	----	----	10.67a (3.34)	13.33f (3.72)	11.67f (3.49)	12.67g (3.63)	11.33g (3.44)	12.67g (3.63)	13.67f (3.76)	10.67a (3.34)	12.67e (3.63)	11.33f (3.44)	13.33f (3.72)	11.33f (3.44)	12.87e (3.63)	13.74f (3.76)
$F_{(2, 6)}$ value			0.264	36.24	45.15	126.21	55.48	48.75	35.14	0.365	21.26	32.16	137.45	58.14	68.45	84.26
P r>F value			0.458	0.0011	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.589	<0.0014	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Note: DBS- Day before spray; DAS- Days after spray; NS- non significant
Figures in parentheses indicate √(x+0.5) transformed value

Table 4: Efficacy of insecticides against Green leafhopper (GLH), *Nephotettix virescens* in Rice during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i.ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif* 2014-15							*Rabi*-2014-15						
			No. of GLH hill^{-1}							No. of GLH hill^{-1}						
			1st Spray				2nd Spray			1st Spray				2nd Spray		
			1 DBS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	1 DBS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
Flonicamid 15% + Fipronil 15% WG	90	300	4.67a (2.27)	2.33c (1.68)	1.67d (1.47)	2.67c (1.78)	2.00d (1.58)	1.33d (1.35)	2.33c (1.68)	5.67a (2.48)	2.33c (1.68)	1.67c (1.47)	3.00c (1.87)	1.67c (1.47)	1.00c (1.22)	2.33d (1.68)
Flonicamid 15% + Fipronil 15% WG	120	400	5.33a (2.41)	1.67a (1.47)	1.00b (1.22)	2.33b (1.68)	0.67b (1.08)	0.67b (1.08)	1.00b (1.22)	5.33a (2.41)	2.00b (1.58)	0.67b (1.08)	2.00a (1.58)	1.33b (1.35)	0.33b (0.91)	1.67b (1.47)
Flonicamid 15% + Fipronil 15% WG	150	500	5.33a (2.41)	1.67a (1.47)	0.67a (1.08)	2.00a (1.58)	0.33a (0.91)	0.00a (0.71)	0.67a (1.08)	6.00a (2.55)	1.67a (1.47)	0.33a (0.91)	2.00a (1.58)	0.67a (1.08)	0.00a (0.71)	1.00a (1.22)
Flonicamid 50% WG	75	150	6.33a (2.61)	2.00b (1.58)	1.33c (1.35)	2.67c (1.78)	1.67c (1.47)	1.00c (1.22)	2.33c (1.68)	4.67a (2.27)	2.33c (1.68)	1.33d (1.35)	2.67b (1.78)	1.33b (1.35)	1.33d (1.35)	2.00c (1.58)
Fipronil 5% SC	75	1500	5.67a (2.48)	3.33e (1.96)	2.33f (1.68)	3.67e (2.04)	2.67e (1.78)	2.33f (1.68)	3.00d (1.87)	4.67a (2.27)	3.00e (1.87)	2.33e (1.68)	3.67e (2.04)	3.00e (1.87)	2.67f (1.78)	3.33f (1.96)
Thiamethoxam 25% WG	25	100	6.00a (2.55)	2.67d (1.78)	2.00e (1.58)	3.00d (1.87)	3.00f (1.87)	2.00e (1.58)	3.67e (2.04)	5.33a (2.41)	2.67d (1.78)	2.33e (1.68)	3.00d (1.87)	2.67d (1.78)	2.33e (1.68)	3.00e (1.87)
Untreated control	----	----	5.00a (2.35)	7.33f (2.80)	6.67g (2.68)	8.67f (3.03)	8.67g (3.03)	8.33g (2.97)	9.33f (3.14)	5.00a (2.35)	7.33f (2.80)	7.67f (2.88)	8.33f (2.97)	11.33f (3.44)	9.67g (3.19)	12.33g (3.58)
$F_{(2, 6)}$ value			0.264	110.26	59.32	48.15	64.26	78.26	45.65	1.03	66.24	59.68	112.34	49.58	36.45	54.56
P r>F value			0.486	<0.0001	<0.0001	0.0010	<0.0001	<0.0001	<0.0001	0.615	<0.0001	0.0012	<0.0001	<0.0001	<0.0001	<0.0001

Note: DBS- Day before spray; DAS- Days after spray; NS- non significant
Figures in parentheses indicate √(x+0.5) transformed value

Table 5: Effect of insecticides on yield and economics of insect pest management of Rice during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i.ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif*, 2014-15		*Rabi*, 2014-15	
			Yield* (Q ha^{-1})	C:B ratio	Yield* (Q ha^{-1})	C:B ratio
Flonicamid 15% + Fipronil 15% WG	90	300	45.34c	2.18	46.74c	2.25
Flonicamid 15% + Fipronil 15% WG	120	400	51.63b	2.24	53.57b	2.54
Flonicamid 15% + Fipronil 15% WG	150	500	54.04a	2.72	56.58a	2.83
Flonicamid 50% WG	75	150	44.54c	2.09	45.25c	2.13
Fipronil 5% SC	75	1500	43.47c	1.93	44.34c	1.97
Thiamethoxam 25% WG	25	100	39.14d	1.96	40.14d	2.01
Untreated control	----	----	34.15e	1.73	34.56e	1.75
$F_{(2, 6)}$ value			56.24	-----	64.35	-------
P r>F value			<0.0001	------	<0.0001	-------

*Mean of 3 replicates

Table 6: Effect of insecticides on important natural enemies of insect pests in Rice ecosystem during *Kharif* and *Rabi* 2014-15

Treatments	Dosage of chemical (g a.i. ha^{-1})	Formulation (g or ml ha^{-1})	*Kharif*, 2014-15						*Rabi*, 2014-15					
			No. of *C. lividipenis*/ 10 hills			No. of Predatory spiders m^{-2}			No. of *C. lividipenis*/ 10 hills			No. of Predatory spiders m^{-2}		
			1 DBS	10 Days after 1st Spray	10 Days after 2nd Spray	1 DBS	10 Days after 1st Spray	10 Days after 2nd Spray	1 DBS	10 Days after 1st Spray	10 Days after 2nd Spray	1 DBS	10 Days after 1st Spray	10 Days after 2nd Spray
Flonicamid 15% + Fipronil 15% WG	90	300	4.67 (2.27)	2.67 (1.78)	3.67 (2.04)	8.33 (2.97)	6.00 (2.55)	4.00 (2.12)	5.33 (2.41)	4.67 (2.27)	5.00 (2.35)	7.33 (2.80)	5.23 (2.39)	5.36 (2.42)
Flonicamid 15% + Fipronil 15% WG	120	400	3.00 (1.87)	3.00 (1.87)	3.33 (1.96)	9.33 (3.14)	6.00 (2.55)	4.33 (2.20)	6.00 (2.55)	3.67 (2.04)	6.33 (2.61)	7.33 (2.80)	4.95 (2.33)	4.75 (2.29)
Flonicamid 15% + Fipronil 15% WG	150	500	3.33 (1.96)	2.33 (1.68)	3.33 (1.96)	8.00 (2.92)	6.67 (2.68)	4.33 (2.20)	6.33 (2.61)	4.00 (2.12)	6.00 (2.55)	7.67 (2.86)	4.68 (2.28)	5.12 (2.37)
Flonicamid 50% WG	75	150	4.67 (2.27)	2.33 (1.68)	3.00 (1.87)	8.33 (2.97)	5.67 (2.48)	3.67 (2.04)	6.67 (2.68)	4.33 (2.20)	5.33 (2.41)	6.67 (2.68)	5.02 (2.35)	4.85 (2.31)
Fipronil 5% SC	75	1500	4.00 (2.12)	2.00 (1.58)	3.00 (1.87)	9.33 (3.14)	6.00 (2.55)	3.67 (2.04)	8.00 (2.92)	4.67 (2.27)	5.33 (2.41)	6.33 (2.61)	5.12 (2.37)	5.34 (2.42)
Thiamethoxam 25% WG	25	100	3.67 (2.04)	3.00 (1.87)	3.67 (2.04)	8.67 (3.03)	6.33 (2.61)	4.00 (2.12)	7.67 (2.86)	4.00 (2.12)	5.67 (2.48)	6.67 (2.68)	4.75 (2.29)	4.67 (2.27)
Untreated control	----	----	3.00 (1.87)	3.33 (1.96)	3.67 (2.04)	9.00 (3.08)	6.33 (2.61)	4.33 (2.20)	7.67 (2.86)	4.67 (2.27)	6.67 (2.68)	7.33 (2.80)	4.56 (2.25)	5.26 (2.40)
$F_{(2, 6)}$ value			64.26	142.35	85.24	44.36	145.34	257.11	55.46	235.48	156.24	148.29	247.65	235.64
P r>F value			0.564	0.365	0.245	0.348	0.452	0.458	0.265	0.441	0.225	0.236	0.415	0.568

Note: DBS- Day before spray; DAS- Days after spray; NS- non significant
Figures in parentheses indicate √(x+0.5) transformed value

4. Conclusion

Findings of the present study suggested that the new pre-mix formulation of Flonicamid 15% + Fipronil 15% WG @ 150 g a.i ha^{-1} was found effective in controlling the major insect pests of rice *viz*., yellow stem borer, leaf folder, BPH and GLH. It was also found safer to natural enemies of rice ecosystem with highest grain yield and B: C ratio.

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