Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(4): 1410-1416

Received: 25-05-2018
Accepted: 26-06-2018

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Evaluation of bioefficacy and phytotoxicity of fipronil 5% SC and acetamiprid 20% SP on rice insect pest complex

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Abstract
Field experiments were conducted on two rice varieties, IET 4786 and Satabdhi to study the bioefficacy of the formulations of fipronil 5% SC and acetamiprid 20% SP at three different doses (20, 50 and 100 gm a.i./ha; and 10, 20 and 40 gm a.i./ha, respectively) against different insect pest complex during 2014 and 2015. Results of the experiment revealed that, highest reduction in dead hearts/ white ears was recorded in fipronil 5% SC @ 75 gm a.i./ha. Similarly, highest reduction in population of leaf hoppers, plant hoppers, gall midge and whorl maggot and highest yields were recorded in plots treated with fipronil 5% SC @ 75 gm a.i./ha. For Acetamiprid 20% SP, highest reduction in brown plant hopper population and highest yields were recorded in the plots with doses 10 and 20 gm a.i./ha. No phytotoxic symptoms were recorded due to any of the insecticides even at higher than field recommended doses. Both the insecticides did not have any severe depressing effect on the natural enemies in the field when applied at recommended doses.

Keywords: Bioefficacy, insecticides, fipronil 5% SC, acetamiprid 20% SP, rice, insect pest complex

Introduction

Rice is an important staple food and major cereal food crop for more than half of the population of the world [10] and being cholesterol free it serves as an important source of carbohydrates. Rice provides 29.4% of the total calories per capita per day in Asian countries [4]. It is known as the king of cereals and about 90% of rice production and consumption is confined within South Asian countries [10]. India is the largest producer of rice with a total area of 42 million ha under cultivation and average yield of 3.7 tonnes per ha [5]. Several insect pests are known to attack rice, of which there are about 20 major insect pests which are amongst the major yield restricting biotic stresses encountered by rice crop [2]. Among the major insect pests, an average yield loss of 30%, 20%, 15% and 10% have been accounted due to yellow stem borer (*Scirpophaga incertulus*), leaf and plant hoppers, gall midge (*Orseolia oryzae*) and leaf folder (*Cnaphalocrocis medinalis*) respectively while another 25% loss in yield have been reported due to other minor insect pests [9]. About 25-30 per cent reduction in yield of rice was reported to have been caused by yellow stem borer (YSB), brown plant hopper (BPH) (*Nilaparvata lugens*), white backed plant hopper (WBPH) (*Sogatella furcifera*) and rice leaf folder in India [12]. In addition to that both GLH and BPH transmit viral diseases like rice tungro virus, grassy stunt virus, rice yellow dwarf, etc. which cause additional yield losses. Rice whorl maggot (*Hydrellia* spp.) is a pest of rice plants only in irrigated ecosystem. However, a report says that the whorl maggot could cause 20-30 per cent yield loss on the first crop during April to September in South India [20]. Another study reported around 41% yield loss due to whorl maggot in untreated rice fields in Philippines [6]. Indiscriminate use of insecticides in higher than required doses led to the development of resistance, which worsened the pest scenario. To overcome such problems, novel insecticidal molecules have been developed which are effective in low doses and have low residual effect on the environment [14]. Fipronil belongs to phenyl pyrazole group of insecticides and was found to be efficient compared to pyrethroid, OP and carbamate insecticides [13]. Fipronil is a broad spectrum insecticide and acts by inhibiting the actions of GABA-gated chloride channels [7] and glutamate-gated chloride channels (GluCl) [15, 21]. In the USA, fipronil has been shown to provide effective control of rice water weevil, whilst in Australia it has been found to be successful as a seed treatment for the control of chironomid midge larvae. Another molecule, acetamiprid, is a broadspectrum neonicotinoid insecticide which has been used in the control of Hemipteran (mainly aphids), Thysanopteran and Lepidopteran pests in a wide range of crops [16]. It has been considered a better substitute to organophosphates because of its systemic and contact activity and relatively low mammalian toxicity [8]. Hence, the present investigation was conducted to study the bio-efficacy of two novel insecticides, fipronil 5% SC on rice yellow stem borer, green leaf hopper, brown plant hopper, white backed plant hopper, rice gall midge and rice whorl maggot, and acetamiprid 20% SP on brown plant hopper. In the same study we have also investigated the phytotoxicity of the said insecticide molecules on rice plant.

2. Materials and methods

2.1 Experimental Site

The experiments were conducted at University Experimental Farm, 'C' Unit, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during kharif seasons (July to November) of 2014 and pre-kharif season (February to June) of 2015. The experimental site is situated under the Gangetic alluvial soil with loamy texture, with good water holding capacity, well drained and moderate fertility status. The bio-efficacy of Fipronil 5% SC was carried out in the kharif season of 2014 and that of Acetamiprid 20 SP was done in the pre-kharif season of 2015.

2.2 Experimental Layout

The experiment was laid out in a Randomized Block Design (RBD) with seven treatment combinations including an untreated check and with three replications. Seedlings were raised in nursery beds and one month old seedlings were transplanted in the field plot size of 5m x 5m and 5m x 4m for fipronil and acetamiprid testing respectively. Spacing between plants was 10 cm and between rows was 15 cm in the main fields in both the experiments. All recommended agronomic package of practices free from pesticide application were adopted for raising the crop. For the experiment conducted on kharif, 2014, the treatments comprised of fipronil 5% SC in different doses i.e. 20, 50 and 100 gm a.i. per ha to find out the most effective dose. Recommended doses of fipronil 5% SC (75 gm a.i. per ha), chlorpyrifos 20% EC (250 gm a.i. per ha) and lambda-cyhalothrin 2.5% EC (12.5 gm a.i. per ha) were applied for comparison. Rice variety IET-4786 was used in the above experiment. For the experiment conducted on pre-kharif 2015, the treatments comprised of acetamiprid 20% SP in different doses i.e. 25 gm/ha (5 gm a.i.), 50 gm/ha (10 gm a.i.), 100 gm/ha (20 gm a.i.) and 200 gm/ha (40 gm a.i.) to find out the most effective dose. Recommended doses of Acelon (acetamiprid 20% SP) @ 50 gm/ha (10 g a.i) and 100 gm/ha (20 g a.i) were applied for comparison. Rice variety Satabdhi was used in this experiment. For the experiment on kharif rice using fipronil, four sprays were made at 15 days interval and for the experiment on pre-kharif rice using acetamiprid, two sprays were made. The first spray was done when the ETL of BPH reached 10 insects/ hill on 22.03.2015 and the second spray was done approximately after a month on 20.04.2015.

2.3 Observations

To record the incidence of targeted insects, two rows were discarded on all sides as border rows and then 10 hills were selected randomly diagonally. The observations on dead heart and white ear head formed due to yellow stem borer were taken 1 day before application (Pre-treatment) and 1, 5, 10 and 15 days after each application (post treatment). The mean percent dead hearts/white ears per plot were worked out after each spray. The percent incidence (Dead hearts/white ears) was calculated as follows:

$$\%\ \text{incidence} = \frac{\text{No. of dead hearts/white ear/hill}}{\text{Total number of tillers/hill}} \times 100$$

For all other insects in the experiment using fipronil, pre-treatment and post treatment count of each insect on 10 randomly selected hills in each plot was taken and mean percent reduction in population of each insect over untreated plot was worked out. Similarly, in the experiment using acetamiprid, the observations on plant hoppers were taken before the first spray and subsequently on 3rd, 7th and 10th days after each spray. Plot wise grain yield was also recorded at harvest and expressed in q/ha. The observations were taken during 6.30 a.m. to 9 a.m. in the morning. The relative efficacy of each treatment was judged on the basis of per cent pest reduction.

The effect of fipronil 5% SC was evaluated against natural enemies in Rice eco-system. Population of natural enemies was recorded by ten net sweepings as pre-treatment and post-treatment counts from all the treated and untreated control plots. The effect of acetamiprid 20% SP on natural enemies prevailing in the rice crop ecosystem was evaluated before first spray and 7 and 14 days after each spray. The population of prevailing predators, unidentified spiders/10 hills and mirid bug (*Cyrtorhinus lividipennis*) / hill was recorded.

For phytotoxicity evaluation, fipronil 5 % SC was applied at the rate of 75, 150 and 300 gm. a.i. /ha. For phytotoxicity evaluation of acetamiprid 20% SP, ten randomly selected plants of 50 DAT were sprayed with the insecticide at the rate of 100 gm /ha (20 g a.i) and 200 gm /ha (40 g a.i). The observations for phytotoxic symptoms were made after 3, 7 and 10 days of spray for leaf injury on tips/surface, wilting, vein clearing, stunting, necrosis, epinasty and hyponasty and the degree of phytotoxicity was expressed following a 0-10 scale. The details are: 0 = 0%, 1= 1-10%, 2= 11-20%, 3= 21-30%, 4= 31-40%, 5= 41-50%, 6= 51-60%, 7= 61-70%, 8= 71-80%, 9= 81-90%, 10= 91-100%.

2.4 Statistical Analysis

All the data obtained at various pre and post spraying periods were subjected to analysis of variance after making necessary transformation wherever needed.

3. Results

3.1 Bio-efficacy of Fipronil 5% SC against insect pests of rice

The formation of dead hearts and white ear heads in the pretreatment count which was done prior to each spraying was found not significant (Table 1). All the treatments were significantly effective in reducing infestation of rice yellow stem borer (YSB) thus reducing the formation of dead hearts and white ear heads significantly as compared to untreated control. Fipronil 5% SC @ 75 gm.a.i./ha showed minimum shoot borer damage/ white ear (1.93%) after fourth spray followed by Fipronil 5% SC @ 50 gm a.i./ha (2.96%) and Fipronil 5% @ 75 gm. a.i./ha (2.99%). The treatments Fipronil 5% SC @ 50 gm a.i./ha and Fipronil 5% @ 75 gm.

a.i./ha were statistically at par with each other. The next best treatment in reducing the infestation was observed in Chlorpyrifos 20 EC @ 250 g a.i./ha (2.06%, 2.60%, 2.93% and 3.13%) followed by Lambda-cyhalothrin 2.5% EC @250 gm a.i./ ha (2.36%, 2.83%, 3.73% and 4.10%) after first, second, third and fourth spray respectively. Fipronil 5% SC @ 30 gm a.i./ha was found least effective in the reduction of dead hearts and white ear heads as compared to other treatments after each spray (Table 1). Similarly, Fipronil 5% SC @ 50 gm a.i./ha and @ 75 gm a.i.,/ha were most effective treatments in reducing percent population (more than 80% reduction in population) of sucking pests viz. Green Leaf Hopper, Rice Leaf Hopper, Brown Plant Hopper, White backed Plant Hipper, Rice gall midge and whorl maggot in rice crop (Table 2). Fipronil 5% SC @ 30 gm a.i. /ha was found to be the least effective treatment in reducing percent population (less than 60% reduction in population) of the above mentioned sucking pests followed by Chlorpyrifos 20 EC @250 gm a.i./ ha (less than 71% reduction in population) (Table 2).

Table 1: Effect of Fipronil 5 % SC on Yellow Stem Borer in Rice crop during Kharif, 2014 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (Mean of four application and three replications).

Sl. No.	Treatments	Dosage		Pre-treatment 1 DBA	% Dead Hearts /White ears after each application			
		g a.i./ha	Formulation ml/ha		1st Spray	2nd Spray	3rd Spray	4th Spray
T_1	Fipronil 5% SC	30	600	5.63 13.53)	4.13 (11.68)	4.66 (12.35)	5.13 (12.96)	5.60 (13.68)
T_2	Fipronil 5% SC	50	1000	5.53 (13.49)	1.63 (7.33)	1.93 (7.89)	2.43 (8.88)	2.96 (9.60)
T_3	Fipronil 5% SC	75	1500	5.03 (12.91)	0.93 (4.53)	1.03 (4.76)	1.46 (6.94)	1.93 (7.92)
T_4	Fipronil 5% SC	75	1500	4.96 (12.87)	1.96 (7.93)	2.46 (8.93)	2.96 (9.91)	2.99 (9.70)
T_5	Chlorpyrifos 20% EC	250	1250	5.16 (12.93)	2.06 (8.17)	2.60 (8.97)	2.93 (9.64)	3.13 (10.04)
T_6	Lambda- cyhalothrin 2.5% EC	12.5	500	4.70 (12.31)	2.36 (8.74)	2.83 (9.47)	3.73 (11.13)	4.10 (11.67)
T_7	Control (Untreated)	-	-	4.83 (12.55)	8.80 (17.23)	8.56 (16.99)	9.06 17.51)	9.33 (17.78)
S E (m)±				NS	1.03	1.32	0.85	0.87
CD (P = 0.05)					3.13	3.99	2.58	2.64

Figures in parentheses are angular transformed values: DBA = Days before application; DAA = Days after application, N.S. - Not significant, SE (m): Standard error of mean, CD: Critical difference at 5 % level of significance

Table 2: Effect of Fipronil 5 % SC on Green Leaf Hopper in Rice crop during Kharif, 2014 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (Mean of four application and three replications).

Sl. No	Treatments	Dosage		Mean percent reduction in population over control					
		gm. a.i./ ha	Formulation ml/ ha	Green Leaf Hopper (GLH)	Rice leaf Hopper	Brown Plant Hopper (BPH)	White Backed Plant Hopper (WBPH)	Rice Gall Midge (SS)	Whorl Maggot (WM)
T_1	Fipronil 5% SC	30	600	58.30 (59.78)	56.80 (48.91)	60.20 (55.67)	57.90 (49.54)	54.40 (47.52)	56.00 (48.45)
T_2	Fipronil 5% SC	50	1000	78.30 (62.24)	77.80 (61.89)	79.00 (62.72)	78.90 (62.65)	78.00 (62.03)	80.10 (63.51)
T_3	Fipronil 5% SC	75	1500	88.40 (70.09)	86.20 (68.19)	90.80 (72.34)	86.90 (68.78)	87.00 (68.87)	88.80 (70.45)
T_4	Fipronil 5% SC	75	1500	75.20 (60.13)	71.90 (57.99)	73.20 (58.82)	74.40 (59.60)	75.50 (60.33)	77.10 (61.41)
T_5	Chlorpyrifos 20% EC	250	1250	68.30 (55.73)	67.90 (55.49)	70.20 (56.91)	68.70 (55.98)	66.40 (54.57)	69.90 (56.79))
T_6	Lambda-cyhalothrin 2.5% EC	12.5	500	70.80 (57.29)	71.30 (57.61)	72.40 (58.31)	71.80 (57.92)	72.90 (58.56)	71.90 (57.99)
T_7	Control (Untreated)	-	-	-	-	-	-	-	-
S Em±				3.1	2.4	2.8	2.4	2.0	2.2
CD (P = 0.05)				9.2	5.2	NS	7.1	5.5	4.5

Figures in parentheses are arcsine /percentage transformed values, N.S. - Not significant, SE (m): Standard error of mean, CD: Critical difference at 5 % level of significance.

3.2 Bio-efficacy of Acetamiprid 20% SP against rice brown plant hopper (BPH)

The pooled data on the effect of the first and second spray of Acetamiprid 20% SP against BPH have been presented in Table 3 and Table 4. All the treated plots showed significant reduction of BPH population in comparison to control plots for both the sprays. However, the plots which were treated with a combination of doses of Acetamiprid 20% SP (25, 50 and 100 gm/ ha) gave almost total control of BPH irrespective of the doses i.e. 5, 10 & 20 gm a.i. /ha. The percentage reduction in the population of BPH in two of the above mentioned treatments (50 and 100 gm/ ha with doses 10 and 20 gm a.i. / ha respectively) were statistically at par. The reduction of BPH population recorded in the three above mentioned treatment plots was significantly superior in comparison to the plots treated with Acelon (Acetamiprid 20% SP). Acelon (Acetamiprid 20% SP) with the dose of 50 gm/ha (10 gm a.i. /ha) provided least control of BPH population after both the sprays (Table 3 and Table 4).

3.3 Effect of insecticidal treatments on yield of rice

Maximum paddy grain yield 42.92 q/ha (58.14% increase over control) was recorded in the plots treated with Fipronil 5% SC @ 75 gm. a.i./ha which was closely followed by Fipronil 5% SC @ 50 gm. a.i./ha with 41.66 q/ha (53.50% increase over control). Grain yield in both the treatments were statistically at par with each other. In Fipronil 5% SC @ 75 gm. a.i./ha the paddy grain yield was 40.40 q/ha (48.85% increase over control). Whereas, in the treatment with Chlorpyrifos 20% EC @ 250 gm a.i. /ha paddy yield was 35.35 q/ha (30.25% increase over control and Lambda-cyhalothrin 2.5% EC had 38.35q/ha (41.30% increase over control) (Table 5). The lowest grain yield was in the plots treated with Fipronil 5% SC @ 30 gm. a.i./ha followed by that of Chlorpyrifos 20% EC @ 250 gm a.i./ha.

In the experiment with Acetamiprid, the yield increase was commensurate with the performance of the treatments. Yield of rice in all treated plots was significantly higher than the control plot (Table 4). The infestation of BPH was of moderate level and thus the differences between the treated plots in terms of yield was relatively close. The highest yields were provided by the treatments with Acetamiprid 20% SP (50 and 100 gm/ ha) and were statistically at par.

Table 3: Effect of 1st spray of Acetamiprid 20% SP against BPH of rice during Mar.-May., 2015 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (based on four replications).

Sl. No	Treatment	Dose	Pre- application count of BPH (No/hill)	% reduction/increase(+) of BPH population on various days after 1st application		
				3rd	7th	10th
1.	Acetamiprid 20% SP	25 gm/ ha (5 g a.i.)	11.33	96.32 (78.94)	96.24 (78.82)	95.41 (77.63)
2.	Acetamiprid 20% SP	50 gm/ ha (10 g a.i.)	10.66	99.99 (89.43)	99.99 (89.43)	99.68 (86.76)
3.	Acetamiprid 20% SP	100 gm/ ha (20 g a.i.)	12.06	100.00 (90.00)	100.00 (90.00)	99.99 (89.43)
4.	Acelon (Acetamiprid 20% SP)	50 gm /ha (10 g a.i)	11.66	81.78 (64.73)	80.14 (63.54)	77.98 (62.01)
5.	Acelon (Acetamiprid 20% SP)	100 gm /ha (20 g a.i)	11.33	91.87 (73.43)	87.03 (68.89)	83.51 (66.04)
6.	Untreated Control (Water spray)	-	11.66	+25.08 (0.00)	+36.12 (0.00)	+59.17 (0.00)
	CD at 5 %		N.S.	1.15	1.60	1.34

Table 4: Effect of 2nd spray of Acetamiprid 20% SP against BPH and yield of rice during Mar. May., 2015 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (based on four replications).

Sl. No	Treatment	Dose	No. of BPH/hill on 10th day after 1st spray	% reduction/increase(+) of BPH population on various days after 2nd application			Yield (q/ha)
				3rd	7th	10th	
1.	Acetamiprid 20% SP	25 gm/ hac (5 g a.i.)	0.66	97.46 (80.83)	97.35 (80.63)	96.86 (79.79)	29.33
2.	Acetamiprid 20% SP	50 gm/ hac (10 g a.i.)	0.33	100.00 (90.00)	100.00 (90.00)	99.99 (89.43)	31.66
3.	Acetamiprid 20% SP	100 gm/ hac (20 g a.i.)	0.06	100.00 (90.00)	100.00 (90.00)	99.99 (89.43)	32.33
4.	Acelon (Acetamiprid 20% SP)	50 gm /hac (10 g a.i)	1.33	83.96 (66.39)	73.57 (59.06)	70.04 (56.81)	26.06
5.	Acelon (Acetamiprid 20% SP)	100 gm /hac (20 g a.i)	1.66	86.36 (68.33)	84.02 (66.44)	80.18 (63.56)	27.66
6.	Untreated Control (Water spray)	-	17.66	+76.14 (0.00)	+103.99 (0.00)	+141.26 (0.00)	24.33
	CD at 5 %		N.S.	1.82	1.97	2.11	1.14

N.S. - Not significant; Figures in parentheses are angular transformed values,
SE (m): Standard error of mean, CD: Critical difference at 5 % level of significance

Table 5: Effect of Fipronil 5 % SC on grain yield in Rice crop during Kharif, 2014at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (Mean of four applications and three replications).

Sl. No.	Treatments	Dosage		Water Litre/ha.	Grain yield (q/ha)	Percent Yield increased over Control
		gm. a.i./ha	Formulation ml/ha			
T_1	Fipronil 5% SC	30	600	500	30.30	11.64
T_2	Fipronil 5% SC	50	1000	500	41.66	53.50
T_3	Fipronil 5% SC	75	1500	500	42.92	58.14
T_4	Fipronil 5% SC	75	1500	500	40.40	48.85
T_5	Chlorpyrifos 20% EC	250	1250	500	35.35	30.25
T_6	Lambda- cyhalothrin 2.5% EC	12.5	500	500	38.35	41.30
T_7	Control (Untreated)	-	-	500	27.14	-

3.4 Effect of insecticidal treatments on natural enemies of rice

The population of predators (like Spiders, *Chrysoperla* sp., Dragon fly and Ladybird Beetle) in all treatments including untreated control 1 day before treatment was almost equal to the population recorded 15 days after last spray. Fipronil 5% SC did not show any adverse effect on natural enemy population at any of its recommended doses. It is clear from the above study that the application of Fipronil 5% SC applied @ 50 - 75gm a.i./ha (the recommended dose) had no adverse effect on the natural enemies presented in the rice eco-system and proved to be eco-friendly while applied on rice crop (Table 6).

Table 6: Effect of Fipronil 5% SC on Natural enemies associated in Rice crop (Mean of four applications and three replications).

Sl. No	Treatments	Dose		Pre-treatment (1DBA) and Post-treatment (15 days after last spray) Predators Populationin rice crop							
		gm. a.i./ha	Formulation	Spiders		Chrysoperla sp.		Lady Bird Beetle		Dragon Fly	
				Pre-treatment	Post - treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
T_1	Fipronil 5% SC (KREPL)	30	600	6.5	6.4	5.1	5.2	5.5	5.6	5.6	5.5
T_2	Fipronil 5% SC (KREPL)	50	1000	6.0	6.0	5.0	4.9	5.4	5.3	5.5	5.4
T_3	Fipronil 5% SC (KREPL)	75	1500	6.3	6.2	5.0	5.0	5.4	5.4	5.7	5.4
T_4	Fipronil 5% SC (Market sample)	75	1500	6.0	5.8	5.2	4.8	5.0	4.8	5.2	5.0
T_5	Chlorpyrifos 20% EC	250	1250	6.0	5.9	4.8	4.6	5.0	5.0	5.0	5.2
T_6	Lambda-cyhalothrin 2.5% EC	12.5	500	5.8	5.6	4.7	4.4	5.0	5.1	5.2	5.2
T_7	Control (Untreated)	-	-	5.8	6.4	5.0	5.6	5.0	5.3	5.4	6.0

DBA- Days after spray, DAA – Days after spray

Table 7: Effect of different treatment schedules of Acetamiprid 20% SP on natural enemies present in Rice Ecosystem during Mar.-May., 2015 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, West Bengal(based on three applications and three replications)

Sl. No	Treatment	Dose product gm /ha	Mean spider population/10 hills		Mean mirid bug population/hill	
			Pre-treatment	Post -treatment	Pre-treatment	Post -treatment
1.	Acetamiprid 20% SP	25	2.67 (1.92)	2.33 (1.53)	5.67 (2.38)	4.67 (2.16)
2.	Acetamiprid 20% SP	50	2.33 (1.82)	1.67 (1.29)	4.33 (2.08)	4.00 (2.00)
3.	Acetamiprid 20% SP	100	1.67 (1.63)	1.33 (1.15)	2.67 (1.63)	2.33 (1.53)
4.	Acelon (Acetamiprid 20% SP)	50	1.33 (1.53)	1.00 (1.00)	2.33 (1.53)	1.33 (1.15)
5.	Acelon (Acetamiprid 20% SP)	100	2.00 (1.73)	1.67 (1.29)	5.33 (2.31)	4.33 (2.08)
6.	Untreated Control (Water spray)	–	2.33 (1.53)	3.67 (2.16)	8.33 (2.89)	10.67 (3.27)
	CD at 5 %	N.s	0. 21	0.19	1.18	1.01

NS – Non significant, Figures in parentheses are square root transformed values,
CD: Critical difference at 5 % level of significance

Table 8: Evaluation of Acetamiprid 20% SP for phytotoxicity on rice during Mar.-May., 2015 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (based on one application and ten replications).

Sl. No.	Treatment	Dose (g a.i. /ha)	Visual rating (phytotoxicity) in 0-10 scale of grading										
			0	1	2	3	4	5	6	7	8	9	10
			0-0.0%	1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
1.	Acetamiprid 20% SP	20	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
2.	Acetamiprid 20% SP	40	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
3.	Untreated control	-	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

NP = No phytotoxicity.
Observation taken for fifteen days on necrosis, epinasty, hyponasty, leaf tip injury, leaf surface injury, wilting, vein clearing etc. on fifty day's old crop.

The population of natural enemies prevailing in the rice crop ecosystem in treatments with Acetamiprid have been presented in Table 7. It was noticed that there was a slight decline in the post-treatments counts of the population of natural enemies viz., spiders and mirid bugs when compared to untreated plots. The highest post-treatment natural enemy count were in the treatment plots with Acetamiprid 20% SP (25 and 50 gm/ ha) and Acelon (Acetamiprid 20% SP) (100 gm/ ha). Out of these treatments, Acetamiprid 20% SP (50 gm/ ha) performed best both in terms of yield of rice and also in terms on controlling BPH population. One of the basic reasons for decline in predator population is a reduction in the pest population.

3.5 Phytotoxic effect of insecticidal treatments on rice plants

Observations recorded for phytotoxicity evaluation of Fipronil 5% SC showed that there were no phytotoxic symptoms in any of the treated plots up to a level of 300 gm. a.i./ha (Table 9). No phytotoxic symptoms were recorded in any of the treated plots with Acetamiprid 20% SP @ 20 & 40 g a.i./ha as mentioned in (Table 8).

4. Discussion

There are several evidences reporting the effectiveness of Fipronil 5% SC and Acetamiprid 20% SP in controlling insect pests of rice. In a study [3], Fipronil 5% SC was found to effectively reduce yellow stem borer and leaf folder damage and did not exhibit any phytotoxic symptoms on rice plants. In another study [1], Fipronil 5% SC was found to show no phytotoxic symptoms on sorghum plants inseedling, vegetative and reproductive stages of crop growth when applied at the rate of 250, 500 and 1000 ml/ ha. In the same study, Fipronil 5% SC was found to reduce sorghum shoot bug and aphid population effectively and also the highest yield was recorded in Fipronil treated plots at the said doses. These reports by previous researchers very well confirm with our study. According to a report [19], the lowest BPH population was found in plots treated with Acetamiprid 20 SP @ 40 gm a.i/ha. Another study [17] assessing toxicity of different insecticides against BPH shows that both LC_{50} and $LC_{97.5}$ values of Monocrotophos 36 WSC was lower than Acetamiprid 20 SP. Hence, Monocrotophos 36 WSC was more toxic to BPH or more effective in controlling BPH than Acetamiprid 20 SP. However, there are several reports on the toxicity of Monocrotophos to pollinators and natural enemies. A series of experiments [18] revealed that insecticides viz., chlorpyriphos, dichlorvos, malathion, profenofos, monocrotophos and deltamethrin when exposed directly or indirectly at their field recommended doses caused very high mortality up to 100% to both the bees (*Apis cerana* and *Apis mellifera*) at 48 hours after treatment. Acetamiprid and Endosulfan were found safer to both the bees either by direct or indirect exposures. Experiments conducted in field conditions and on potted mustard plants showed monocrotophos as a highly toxic insecticide with 100% mortality of bees followed by thiamethoxam, dichlorvos, profenofos and chlorpyriphos which were not recommended for use in pollinator attractive flowering plants. That Acetamiprid and Endosulfan did not cause any repellent effect on honey bees in the field trials endorse the usage of Acetamiprid against sucking pest in flowering plants. No phytotoxic symptoms were observed on sorghum when Acetamiprid 20 SP was sprayed at the rate of 100 gm/ ha [11]. In the same study [17], both LC_{50} and $LC_{97.5}$ values of Fipronil 5% SC was lower than Acetamiprid 20 SP. Hence, Fipronil 5% SC was more toxic to BPH or more effective in controlling BPH than Acetamiprid 20 SP. However, from our study and obtained results, we cannot essentially conclude that Fipronil 5% SC was better than Acetamiprid 20 SP in controlling BPH populations. Both the experiments were carried out in completely different environmental conditions/ cropping seasons, on different rice varieties (Fipronil 5% SC was tested on IET 4786 and Acetamiprid 20 SP was tested on Satabdhi) and it might be highly possible that the environmental conditions prevailing during the two experiments did not support/ discourage BPH populations equally. Our results are in conformity which those of previous researchers about the efficacy of Acetamiprid 20 SP (applied @ 5, 10 & 20 gm a.i./ha) and Fipronil 5 SC (applied @ 50-75 gm a.i./ha) against insect pests of rice and its safety to non-target organisms. However, future research should be carried out to compare the bio-efficacy of both Fipronil 5 SC and Acetamiprid 20 SP in the same cropping season and on the same rice variety to conclude on the best performing insecticide among the two. Besides, the toxicity of these insecticides should also be tested on important egg parasitoids like *Trichogramma japonicum*, *Trichogramma chilonis* and *Platygaster oryzae*.

Table 9: Evaluation of for Phytotoxicity of Fipronil 5 % SC on rice during Kharif 2014 at University Experimental Farm, 'C' Unit, BCKV, Kalyani, Nadia, West Bengal (based on one application and three replications).

Sl. No	Treatment	Dose gm. a.i./ha	Scorching			Vein Clearing			Wilting			Yellowing			Stunting			Necrosis			Epinesty			Hyponesty		
			3	7	10	3	7	10	3	7	10	3	7	10	3	7	10	3	7	10	3	7	10	3	7	10
T_1	Fipronil 5% SC (KREPL)	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	Fipronil 5% SC (KREPL)	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	Fipronil 5% SC (KREPL)	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

N.B. = Observation taken up to ten days of spray on necrosis, epinasty, hyponasty, leaf tip injury, leaf surface injury, on fifty days old crop.

5. Acknowledgement

Authors are grateful to the Head, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, W.B, India for providing all facilities during the entire period of experiment. We also acknowledge M/s Krishi Rasayan Exports Private Limited., New Delhi and M/s Coromandel Agrico Pvt. Ltd, New Delhi for providing the facilities and sample of ready formulation of the insecticides for the experiments.

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