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Pankaj Kumar Mohanta
Research Scholar, Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Utter Pradesh, India

SVS Raju
Professor, Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Utter Pradesh, India

GS Giri
Department of Entomology, Tirhut College of Agriculture, Dholi under RPCAU, Pusa Samastipur, Bihar, India

Corresponding Author:
Pankaj Kumar Mohanta
Research Scholar, Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Utter Pradesh, India

Bio-efficacy of certain insecticidal molecules against lepidopteran pests of rice

Pankaj Kumar Mohanta, SVS Raju and GS Giri

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Abstract
Rice is one of the most important food crops grown worldwide. Though we use almost of the improved agronomic practices, we can not get optimum production and productivity. The reason behind its low productivity includes several factors. Among them insect pest infestation is prime and most important one. Among several insect pests, pests of lepidopteran order such as yellow stem borer and leaf folder are considered as most destructive and responsible for severe yield losses. As the larva are found inside the stem or within the leaf fold, cultural, mechanical, physical methods of pest management are not as effective as chemical control in reducing the pest population. So the present investigation was carried out in order to find out the efficacy of certain chemicals against lepidopteran pests infesting rice.

Keywords: Lepidopteran pest, yellow stem borer, leaf folder, management, bio-efficacy

Introduction
Rice (*Oryza sativa* L.) is one of the mostly grown crops in the world and is the most important staple food of over half the world's population (Khush, 1997) [4]. Approximately, 750 million of the world's poor people depend on rice to survive (Zeigler, 2006) [9]. It is grown practically in all the tropical, sub-tropical and calm nations of the world. Among the several limiting factors for getting improved yields, insect-pests infestation is the prime and the most restraining factor in the successful cultivation of rice. More than 100 species of insects attack rice and among them 20 have potential to cause economic damage all over the world, causing more than 30 per cent yield loss from seedling to maturity (Cramer, 1967; Pathak and Dhaliwal, 1981 and Athwal and Dhaliwal, 2005) [2, 5, 1]. Some of them are Yellow stem borer (*Scirpophaga incertulas*), Leaf folder (*Cnaphalocrocis medanalis*), Gall midge (*Orseolia oryzae*), Brown plant hopper (*Nilparvata lugens*), Green leaf hopper (*Nephotettix nigropictus*, *Nephotettix virescens*), Gundhi bug *(Leptocorisa acuta)*, Case worm (*Nymphula depunctalis*) and several others. Among quite a few insect pests linked with rice, pests of lepidopteran order are considered to be highly destructive.
However, timely application of insecticides is the only and most commonly used measure for reducing pest population and sometimes the only practical solution to sudden outbreaks of insect pests in general. Thus it is imperative that alternate insecticides be explored for managing the pests. New molecules will be searched in the context of effective against rice pest as well as eco-friendly should be given top priority.

Materials and Methods
The experiment was carried out during the *kharif* season of 2018-19 at the Agricultural Research Farm, Banaras Hindu University, Varanasi (Uttar Pradesh) which is situated at latitude of 24° 56' N to 25° 35' N and longitude of 82° 14' E to 83° 24' E with an altitude of 82 m above the mean sea level (MSL). The place is situated in the centre of Indo-gangetic belt, falling under the sub-humid and sub-tropical climate zone
Pests monitoring was done at regular intervals in the current experiment and when the economic threshold levels were reached in terms of pest population / damage, insecticides were sprayed as per the schedule laid out in two sprays:

First Spray	10th October 2018
Second Spray	30th October 2018

Table 1: Treatment details

Treatments	Technical name	Dose(g a.i./ha)	Source
T_1	Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	Gharda chemicals limited
T_2	Fipronil 5% SC	75	Gharda chemicals limited
T_3	Buprofezin 25% SC	200	Gharda chemicals limited
T_4	Fipronil 40% + Imidacloprid 40% WG	50 + 50	Gharda chemicals limited
T_5	Fipronil 5% + Buprofezin 20% SC	62.5 + 200	Gharda chemicals limited
T_6	Thiamethoxam 25% WG	25	Gharda chemicals limited
T_7	Indoxacarb 14.5% SC	30	Gharda chemicals limited
T_8	Imidacloprid 17.8 SL	25	Gharda chemicals limited
T_9	Quinalphos 25% EC	375	Gharda chemicals limited
T_{10}	Control	-	-

Observation

Stem borer

From 10 randomly selected hills, counts were taken about the number of dead hearts/ white ears and total number of tillers/ panicles. The counts were taken one day before application and 1, 3, 5, 7, 10, 14 days after application of chemicals. The per cent incidence (dead heart/ white ears) was calculated as follows:

$$\text{Percent Incidence} = \frac{\text{Number of dead hearts/white ears}}{\text{Total number of tillers /panicles}} \times 100$$

Leaf folder

10 hills were selected at random and recording was done regarding the damaged leaves and total leaves in each plot. The counts were taken one day before application and 1, 3, 5, 7, 10, 14 days after application of chemicals. The percentage of leaf damage caused by leaf folder was calculated by using following formula.

$$\text{Percent Incidence} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Result and discussion

Effect of insecticidal treatments against Yellow stem borer, *S. incertulas*on Rice

The outcomes of the effect of insecticidal treatments after first and second insecticidal application on yellow stem borer were represented in table-2. The initial per cent dead hearts in different experimental plots including untreated control one day before first insecticidal spray was found in a range of 6.47 to 7.63 percent. One day after spray, the mean percent dead hearts was witnessed to be low in Fipronil 5% SC (5.53%) and Indoxacarb 10% + Thiamethoxam 10% WG (5.57%) followed by Indoxacarb 14.5% SC (5.87%) treated plots and differed significantly from rest of the insecticidal treated plots along with the untreated plot.

Three days after spray all the treatments were significant over untreated control and the per cent dead hearts was found to be lowest in plots treated with Fipronil 5% SC (4.87%) and this treatment differed significantly from the mean per cent dead hearts noticed in rest of the plots, except for the plots receiving Indoxacarb 10% + Thiamethoxam 10% WG (4.97%). The plots treated with Indoxacarb 14.5% SC (5.13%) and Fipronil 40% + Imidacloprid 40% WG (5.37%) also significantly differed in their field efficacy from Buprofezin 25% SC and Quinalphos 25% SC treated plots. The observations on 5 days after spray showed that lowest per cent dead hearts were noticed in plots treated with Fipronil 5% SC (2.97%) and differed significantly with the rest of the insecticidal treatments. This treatment is followed by Indoxacarb 10%+ Thiamethoxam 10% WG (3.27%), Indoxacarb 14.5% SC (3.67%) and Fipronil 40% + Imidacloprid 40% WG (3.87%). But, the mean per cent dead hearts was significantly low in plots receiving various test chemicals compared to untreated control (7.47%).

On 7th day after spraying, a significant reduction in per cent dead hearts was observed in all insecticide treated plots. But, the mean per cent dead hearts were least in plots treated with Fipronil 5% (2.27%) and this treatment differed significantly from rest of the insecticide treatments. A highest per cent of dead hearts was observed in Buprofezin 25% SC (4.17%) and Imidacloprid 17.8 SL (3.97%) treated plots. Mean per cent dead hearts per 10 hills during 10th and 14th days after spraying again showed that Fipronil 5% SC treatment had low per cent dead hearts of 3.87% and 4.53% respectively. This treatment is followed by Indoxacarb 10% + Thiamethoxam 10% WG (4.23%) and (4.93%).

Table 2: Effect of insecticidal treatments against Yellow stem borer, *S. incertulas* after 1st insecticidal sprays

Treatments	Dose (g a.i./ha)	Mean% DH/ 10 hills one day before spray	Mean percent DH per 10 hills at different days after 1st insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	7.00* (15.32)**	5.57 (13.64)	4.97 (12.87)	3.27 (10.41)	2.47 (9.03)	4.23 (11.87)	5.93 (14.09)	4.41
Fipronil 5% SC	75	6.47 (14.71)	5.53 (13.60)	4.87 (12.74)	2.9 7(9.91)	2.27 (8.65)	3.87 (11.33)	4.53 (12.29)	4.01
Buprofezin 25% SC	200	7.07 (15.40)	7.07 (15.38)	6.37 (14.61)	5.37 (13.39)	4.17 (11.77)	6.07 (14.25)	7.37 (15.74)	6.07
Fipronil 40% + Imidacloprid 40% WG	50 + 50	7.63 (16.02)	6.17 (14.37)	5.37 (13.39)	3.87 (11.33)	2.83 (9.68)	4.73 (12.56)	6.33 (14.57)	4.88
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	6.57 (14.84)	6.33 (14.57)	5.57 (13.64)	4.27 (11.91)	3.20 (10.30)	5.03 (12.96)	5.63 (14.92)	5.17
Thiamethoxam 25% WG	25	7.13 (15.45)	6.47 (14.73)	5.77 (13.89)	4.63 (12.42)	3.37 (10.57)	5.23 (13.22)	6.77 (15.07)	5.37
Indoxacarb 14.5% SC	30	6.97 (15.18)	5.87 (14.01)	5.13 (13.09)	3.67 (11.03)	2.63 (9.33)	4.53 (12.29)	6.27 (14.49)	4.68
Imidacloprid 17.8 SL	25	7.13	6.63	5.83	4.93	3.63	5.63	6.93	5.60

		(15.45)	(14.92)	(13.97)	(12.83)	(10.98)	(13.72)	(15.26)	
Quinalphos 25% EC	375	7.03 (15.37)	6.77 (15.07)	6.17 (14.37)	5.17 (13.13)	3.97 (11.48)	5.83 (13.97)	7.23 (15.59)	5.86
Control		6.70 (14.92)	7.67 (16.07)	7.77 (16.17)	7.47 (15.85)	7.63 (16.03)	8.37 (16.81)	8.67 (17.11)	7.93
SE(m)±		0.75	0.04	0.07	0.04	0.04	0.05	0.06	-
C.D.at 5%		-	0.12	0.22	0.12	0.12	0.16	0.19	-

*Mean of three replications, **Figures in the parenthesis are Angular transformed values, DAS – Days after spray, DH-Dead heart

Table 3: Effect of insecticidal treatments against Yellow stem borer, *S. incertulas* after 2nd insecticidal spray

Treatments	Dose (g a.i./ha)	Mean% DH/ 10 hills one day before spray	Mean percent DH per 10 hills at different days after 2nd insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	5.40* (13.42)**	4.47 (12.19)	3.83 (11.28)	2.47 (9.03)	2.07 (8.26)	3.17 (10.25)	3.43 (10.67)	3.24
Fipronil 5% SC	75	4.83 (12.69)	4.30 (11.95)	3.47 (10.71)	2.20 (8.52)	1.73 (7.56)	2.87 (9.74)	3.10 (10.14)	2.94
Buprofezin 25% SC	200	6.67 (14.96)	5.50 (13.56)	4.60 (12.38)	4.33 (12.01)	3.80 (11.23)	4.73 (12.55)	5.03 (12.96)	4.67
Fipronil 40% + Imidacloprid 40% WG	50 + 50	5.70 (13.81)	4.63 (12.42)	3.93 (11.43)	2.87 (9.74)	2.57 (9.21)	3.27 (10.41)	3.53 (10.83)	3.47
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	5.87 (13.99)	4.67 (12.46)	3.97 (11.48)	3.03 (10.03)	2.73 (9.51)	3.30 (10.46)	3.73 (11.13)	3.57
Thiamethoxam 25% WG	25	5.90 (14.05)	4.70 (12.51)	4.03 (11.58)	3.17 (10.24)	2.87 (9.74)	3.57 (10.88)	3.83 (11.29)	3.69
Indoxacarb 14.% SC	30	5.27 (13.26)	4.57 (12.33)	3.87 (11.34)	2.83 (9.69)	2.33 (8.78)	3.23 (10.35)	3.47 (10.71)	3.38
Imidacloprid 17.8 SL	25	5.83 (13.95)	4.87 (12.74)	4.17 (11.77)	3.33 (10.51)	3.10 (10.13)	3.83 (11.29)	4.03 (11.58)	3.89
Quinalphos 25% EC	375	6.40 (14.64)	4.93 (12.82)	4.40 (12.09)	3.87 (11.34)	3.47 (10.72)	4.33 (12.01)	4.57 (12.33)	4.26
Control		8.40 (16.84)	8.60 (17.04)	8.20 (16.63)	9.10 (17.54)	8.80 (17.24)	9.70 (18.14)	9.73 (18.17)	9.02
SE(m)±		0.37	0.25	0.18	0.17	0.17	0.16	0.18	
C.D.at 5%		1.10	0.76	0.54	0.51	0.50	0.47	0.54	

*Mean of three replications, **Figures in the parenthesis are Angular transformed values, DAS – Days after spray, DH-Dead hearts

The overall mean of per cent dead hearts per 10 hills of post spraying counts after first insecticidal spray were in order of: Fipronil 5% SC (4.01%) < Indoxacarb 10% + Thiamethoxam 10% WG (4.41%) < Indoxacarb 14.5% SC (4.68%) < Fipronil 40%+ Imidacloprid 40% WG (4.88%) < Fipronil 5% +Buprofezin 20% SC (5.17%) < Thiamethoxam 25% WG (5.37%) < Imidacloprid 17.8 SL (5.60%) < Quinalphos 25% EC (5.86%) < Buprofezin 25% SC (6.07%) < Control (7.93%).

The outcomes regarding the influence of different insecticidal treatments against *S. incertulas* in terms of mean per cent white ears after second sprays were shown in table-3 as the crop was in reproductive stage. The initial per cent white ears was in range from 4.83 to 8.40 per cent per 10 hills one-day preceding to second spray in all the treatments including control. The performances of different insecticidal treatments during second spray were similar to that of first spray. One day after second spray, all the treatments were significantly superior over untreated control and in Fipronil 5% SC treated plots a low per cent white ear damage of 4.30% was recorded. Fipronil 5% SC treated plot again recorded low per cent white ear damage on 3rd and 5th days after spray with 3.47 and 2.20 per cent white ears per 10 hills, respectively. On 7th day, a significant drop in the mean per cent white ears was witnessed in all insecticidal treated plots and in Fipronil 5% SC treated plots, a mean per cent of 1.73 white ear per 10 hills was recorded succeeded by Indoxacarb 10% + Thiamethoxam 25% WG (2.07%) and Indoxacarb 14.5% SC (2.33%). The plots treated with Buprofezin 25% SC (3.80%) recorded the highest per cent of white ear.

All treatments showed a slight increase in the mean per cent white ear damage on 10 and 14 day after spray, but maintained below ETL. During 10th day after spray, the Fipronil 5% SC treated plots showed lowest per cent of white ears (2.87%), which is again significantly low and a high per cent white ear heads witnessed in plots treated with Buprofezin 25% SC (4.73%). On 14th day Fipronil 5% SC treated plot still showed low per cent white ear (3.10%) per 10 hills followed by Indoxacarb 10% + Thiamethoxam 10% WG (3.24%) and least performance was recorded from sole Buprofezin 25% SC (5.03%) treated plot.

The overall mean of per cent white ear per 10 hills of post spraying counts after second insecticidal spray were found to be in order of: Fipronil 5% SC (2.94%) < Indoxacarb 10% + Thiamethoxam 10% WG (3.24%) < Indoxacarb 14.5% SC (3.38%) < Fipronil 40%+ Imidacloprid 40% WG (3.47%) < Fipronil 5% +Buprofezin 20% SC(3.57%) < Thiamethoxam 25% WG (3.69%) < Imidacloprid 17.8 SL (3.89%) < Quinalphos 25% EC (4.26%) < Buprofezin 25% SC (4.67%) < control (9.02%).

Effect of insecticidal treatments against Leaf folder, *C. medinalis* on rice

The results on the influence of insecticidal treatments against rice leaf folder, *C. medinalis* after first insecticidal spray were represented in Table-4. The per cent of leaf damage were in the range of 10.30 to 12.53 per cent per 10 hills, one day prior to insecticidal sprays. One day after spray, a low mean per cent leaf damage of 9.52 and 9.68 per 10 hills were recorded in Fipronil 5% SC and Indoxacarb 10% + Thiamethoxam

10% WG treated plots, respective that differed significantly with other treatments plots but statistically at par with each other. The mean per cent leaf damage was lowest in Fipronil 5% SC (7.41%) treated plots and differed significantly from the mean per cent leaf damage witnessed in rest of the insecticidal treated

Table 4: Effect of insecticidal treatments against Leaf folder, *C. medinalis* after 1st insecticidal sprays

Treatments	Dose (g a.i./ha)	Mean% leaf damage/ 10 hills one day before spray	Mean percent leaf damage per 10 hills at different days after 1st insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	10.67* (19.05)**	9.68 (18.12)	7.76 (16.17)	5.49 (13.55)	4.19 (11.81)	5.04 (12.96)	5.91 (14.06)	6.35
Fipronil 5% SC	75	12.15 (20.39)	9.52 (17.96)	7.41 (15.79)	5.33 (13.34)	3.98 (11.50)	4.93 (12.82)	5.80 (13.92)	6.16
Buprofezin 25% SC	200	11.79 (20.07)	10.87 (19.24)	8.73 (17.18)	6.15 (14.35)	5.15 (13.12)	5.95 (14.11)	6.60 (14.88)	7.24
Fipronil 40% + Imidacloprid 40% WG	50 + 50	11.46 (19.78)	9.92 (18.35)	7.93 (16.35)	5.74 (13.86)	4.37 (12.06)	5.34 (13.36)	6.03 (14.21)	6.56
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	12.45 (20.65)	10.09 (18.51)	8.06 (16.49)	5.79 (13.92)	4.55 (12.31)	5.41 (13.45)	6.14 (14.34)	6.67
Thiamethoxam 25% WG	25	12.53 (20.72)	10.35 (18.76)	8.18 (16.61)	5.92 (14.08)	4.75 (12.58)	5.58 (13.65)	6.19 (14.40)	6.83
Indoxacarb 14.5% SC	30	12.06 (20.31)	9.76 (18.20)	7.78 (16.18)	5.61 (13.69)	4.26 (11.90)	5.23 (13.21)	5.94 (14.10)	6.43
Imidacloprid 17.8 SL	25	11.78 (20.06)	10.49 (18.89)	8.29 (16.73)	5.94 (14.10)	4.98 (12.89)	5.75 (13.87)	6.36 (14.60)	6.97
Quinalphos 25% EC	375	11.38 (19.70)	10.64 (19.03)	8.65 (17.09)	6.03 (14.20)	5.08 (13.02)	5.79 (13.91)	6.43 (14.68)	7.10
Control		10.30 (18.70)	10.56 (18.96)	11.09 (19.44)	11.75 (20.03)	12.38 (20.58)	12.99 (21.11)	13.58 (21.60)	12.06
SE(m)±		0.26	0.09	0.17	0.15	0.17	0.16	0.22	-
C.D.at 5%		0.79	0.28	0.50	0.45	0.50	0.49	0.66	-

*Mean of three replications, **Figures in the parenthesis are Angular transformed values, DAS – Days after spray

Table 5: Effect of insecticidal treatments against Leaf folder, *C. medinalis* after 2nd insecticidal sprays

Treatments	Dose (g a.i./ha)	Mean% leaf damage/ 10 hills one day before spray	Mean percent leaf damage per 10 hills at different days after 2nd insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	8.82* (17.26)**	6.30 (14.53)	4.28 (11.94)	2.91 (9.81)	1.87 (7.85)	2.34 (8.78)	2.81 (9.65)	3.42
Fipronil 5% SC	75	8.30 (16.73)	6.25 (14.47)	4.22 (11.85)	2.87 (9.75)	1.48 (6.98)	2.16 (8.44)	2.67 (9.40)	3.28
Buprofezin 25% SC	200	8.95 (17.39)	7.02 (15.36)	5.05 (12.98)	4.01 (11.55)	3.38 (10.58)	3.63 (10.97)	4.23 (11.86)	4.56
Fipronil 40% + Imidacloprid 40% WG	50 + 50	8.98 (17.42)	6.44 (14.69)	4.34 (12.02)	3.16 (10.23)	2.16 (8.45)	2.73 (9.50)	3.26 (10.39)	3.68
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	8.70 (17.14)	6.54 (14.81)	4.47 (12.20)	3.24 (10.37)	2.29 (8.69)	2.58 (9.23)	3.37 (10.57)	3.75
Thiamethoxam 25% WG	25	9.38 (17.82)	6.59 (14.86)	4.52 (12.27)	3.46 (10.71)	2.54 (9.16)	2.85 (9.71)	3.59 (10.92)	3.93
Indoxacarb 14.5% SC	30	8.96 (17.40)	6.38 (14.62)	4.30 (11.96)	3.02 (10.01)	1.96 (8.04)	2.56 (9.20)	3.10 (10.14)	3.55
Imidacloprid 17.8 SL	25	9.03 (17.47)	6.77 (15.07)	4.65 (12.45)	3.71 (11.10)	2.79 (9.60)	3.07 (10.09)	3.70 (11.08)	4.12
Quinalphos 25% EC	375	8.38 (16.81)	6.91 (15.23)	5.01 (12.92)	3.95 (11.45)	3.07 (10.08)	3.22 (10.34)	3.85 (11.30)	4.33
Control		12.42 (20.62)	12.99 (21.11)	13.74 (21.74)	14.69 (22.52)	13.27 (21.34)	11.88 (20.14)	18.62 (25.55)	14.20
SE(m)±		0.34	0.14	0.24	0.09	0.27	0.27	0.16	
C.D.at 5%		1.02	0.42	0.70	0.28	0.82	0.82	0.49	

*Mean of three replications, **Figures in the parenthesis are Angular transformed values, DAS – Days after spray

plots during 3rd day after spray. The treatment Indoxacarb 10% + Thiamethoxam 10% WG (7.76%) was statistically at par with Indoxacrb 14.5% SC (7.78%). Quinolphos 25% EC (8.65%) was statistically at par with Buprofezin 25% SC (8.73%). A significant fall in the mean per cent damage was observed on 5 days after spray in all insecticidal treated plots and mean per cent leaf damage was lowest in Fipronil 5% SC (5.33%) and Indoxacarb 10% + Thiamethoxam 10% WG (5.49%) treatments and differed significantly with the rest of the insecticidal treatments. Fipronil 40% + Imidacloprid 40% WG (5.74%) was found at par with Fipronil 5% + Buprofezin 20% SC (5.79%). Among insecticidal treatments, the mean per cent damage was as high as 6.03 and 6.15 per 10 hills in Quinalhos 25% SC and Buprofezin 25% SC treated plots, respectively.

On 7th day after spraying, the treatment Fipronil 5% SC

resulted in lowest per cent of leaf damage (3.98%), followed by Indoxacarb 10% + Thiamethoxam 10% (4.19%) and Indoxacarb 14.5% SC (4.26%). A high mean per cent leaf damage of 5.08 and 5.15 per 10 hills were observed in Quinalphos 25% EC and Buprofezin 25% SC treated plots, respectively.

During 10th days after spray Fipronil 5% SC treated plots resulted in least per cent leaf damage of 4.93% and highest per cent leaf damage in plots treated with Buprofezin 25% SC (5.95%). On 14th day after spraying, also least per cent leaf damage was found in plots treated with Fipronil 5% SC (5.80%) and highest percent leaf damage in plots treated with Buprofezin 25% SC (6.60%) and differed significantly from the rest of the insecticidal treatments.

The treatment fipronil 5% SC resulted in lowest per cent leaf damage per 10 hills after first insecticidal spray (6.16%) and the mean per cent leaf damage per 10 hills in the remaining insecticidal treated plots were found to be in the following order: Fipronil 5% SC (6.16%) < Indoxacarb 10% + Thiamethoxam 10% WG (6.35%) < Indoxacarb 14.5% SC(6.43%) <Fipronil 40%+ Imidacloprid 40% WG (6.56%) < Fipronil 5% + Buprofezin 20% SC (6.67%)< Thiamethoxam 25% WG (6.83%) < Imidacloprid 17.8 SL (6.97%) <Quinalphos 25% EC (7.10%) < Buprofezin 25% SC (7.24%) < Control (12.06%).

The influences of various insecticidal treatments against *C. medinalis* in terms of mean per cent leaf damage per 10 hills after second spray were represented in Table-4. One-day before second spray, the mean per cent leaf damage per 10 hills ranged from 8.30 to 12.42 in all the treatments including control. A day after spray, all the insecticide treatments were superior with control plots and differed significantly with each other. Fipronil 5% SC (6.25%) treated plots were recorded with low per cent leaf damage and on 3rd and 5th days after insecticidal treatments, the lowest per cent leaf damage per 10 hills were noted as 4.22 and 2.87 correspondingly.

On 7th day after spray again in Fipronil 5% SC treated plots recorded a low per cent of leaf damage 1.48 per 10 hills succeeded by plots treated with Indoxacarb 10% + Thiamethoxam 10% WG (1.87%) and Indoxacrarb 14.5% SC (1.96%). The highest per cent damage was recorded in plots treated with Quinalphos 25% EC (3.07%) and Buprofezin 25% SC (3.38%).

The per cent leaf damage per 10 hills during 10th and 14th days after spray were significantly low again in Fipronil 5% SC treated plots as 2.16 and 2.67 per cent per 10 hills, respectively and corresponding highest per cent leaf damage of 3.63 and 4.23 per 10 hills, respectively were recorded from Buprofezin 25% SC treated plots.

The overall mean per cent damage per 10 hills on different days of observations after second insecticidal spray were found to be in following order: Fipronil 5% SC (3.28%) < Indoxacarb 10% + Thiamethoxam 10% WG (3.42%) < Indoxacarb 14.5% SC (3.55%) < Fipronil 40%+ Imidacloprid 40% WG (3.68%) < Fipronil 5% +Buprofezin 20% SC (3.75%) < Thiamethoxam 25% WG (3.93%) < Imidacloprid 17.8 SL (4.12%) < Quinalphos 25% EC (4.33%) < Buprofezin 25% SC (4.56%) < Control (14.20%).

Conclusion

The best treatment in reducing dead hearts and white ears was found to be Fipronil 5% SC @ 75 g a.i. / ha. The next best treatments are Indoxacarb 10% + Thiamethoxam 10% WG @ 50 + 50 g a.i. / ha (combination of systemic and contact insecticide), followed by sole indoxacarb 14.5% SC @ 30 g a.i. / ha. This was in accordance with Dash and Mukherjee (2003) [3] who also reported fipronil was more effective in managing stem borer in comparision to other treatments. Singh *et al.* (2005) [8] also gave similar observations.

In the present study sole treatment of Fipronil 5% SC @ 75 g a.i. / ha was found to be effective against *C. medinalis*, followed by a combination of Indoxacarb 10% + Thiomethoxam 10WG @ 50 + 50 g a.i. / ha treatment stood second. The third and fourth performing treatments are Indoxacarb 14.5SC @ 30 g a.i. / ha and Fipronil 40%+ Imidacloprid 40% WG @ 50 + 50 g a.i. / ha. However, it was reported by Sharma & Srivastava (2009) [6] and Zainab & Singh (2016) [10-11] that Fipronil was most effective against rice leaf folder in combination with other contact or systemic insecticides. However, Sharma *et al.* (2018) [7] stated that Fipronil +Buprofezin is most effective against leaf folder, followed by combination of Indoxacarb 10% + Thiamethoxam 10% WG. It is obvious that phenyl pyrazole and combination of phenyl pyrazole with chitin synthesis inhibitor provided effective result against rice yellow stem borer and leaf folder.

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