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Bio-efficacy of insecticides against rice stem borer, *Scirpophaga* spp.

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Abstract
An experiment was conducted during *kharif* 2014-15 to 2016-17 at Main Rice Research Centre, Navsari Agricultural University, Navsari to test the efficacy of some insecticides against rice stem borer, *Scirpophaga* spp. Among all the insecticides tested, treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litres was found most effective in controlling rice stem borer, *S. spp*. The next best treatment was chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litres and thiacloprid 21.7 SC 0.02 @ 10 ml/10 litres in terms of reduction of stem borer population. The highest grain yield of rice (6146 kg/ha) was recorded in the treatment flubendiamide 20 WG 0.005 @ 2.5 gm/10 litres which were followed by chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litres (5919 kg/ha), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (5784 kg/ha) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (5662 kg/ha). As far as straw yield, treatment of flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre was found the highest straw yield (7151 kg/ha) and it was followed by the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (6899 kg/ha), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (6777 kg/ha) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (6556 kg/ha). In terms of ICBR the treatment flubendiamide 20 WG 0.005 @ 2.5 gm/10 litres was found most superior over the rest of the treatments.

Keywords: stem borer, *Scirpophaga* spp., efficacy, insecticides, rice

Introduction
Rice, *Oryza sativa* Linnaeus is one of the most important cereal crop and staple food of more than 65 per cent of world's population and known as a "King of cereals". Rice, *Oryza sativa* L. belongs to grass family Poaceae, sub family Oryzoidae. Asia is considered to be 'rice bowl' of the world, where more than 90 % of world's rice is produced and consumed. Rice is one of the most important food crops of India in term of both area and production. India is the second largest producer and consumer of rice in the world. Out of 148.36 million hectares area of the world under rice cultivation with 519.86 million tonnes of annual production. In India, it is grown in 44.40 million hectares in diverse ecological condition with an annual production of 104.80 million tones and productivity of 2462 kg/ha (Anonymous, 2015) [1]. India is the largest rice growing country in the world but its productivity per unit area is low as compared to the world average. Due to its wide climatic adaptability, large number of insect-pest attacked on rice crop throughout the crop season. Insect pests attack all portions of the rice plant and growth stages. There are several factors responsible for low productivity of rice crop like improper cultivation practices, imbalance use of fertilizers, weeds and pests as well as disease problems. The rice plant is attacked by more than 100 species of insects and 20 of them can cause serious economic loss (Pathak, 1977) [10]. Insect pests like stem borer (SB), leaf folder (LF), rice skipper (SKP), gall midge (GM), gundhi bug (GB), brown plant hopper (BPH) and white-backed plant hopper (WBPH) cause serious damage to rice crop which is responsible for reducing rice yield. Among these, rice stem borers have been mainly responsible for keeping the crop under stress over the years and across rice ecosystem in Gujarat and also throughout the country. The most prevalent species in India are *Scirpophaga incertulas* (walker), *Chilo suppressalis*, *Scirpophaga innotata* (walker). The yield losses ranged from 3 to 65 per cent (Ghose *et al.*, 1960) [3] as well as (Pathak, 1977) [11]. Yield loss due to insect pests of rice has been estimated about 30-40% (Henrich *et al*., 1979). The rice stem borers are the principal devastators and responsible for economic crop losses under field condition (Mahar and Hakro, 1979) [8]. They are common and serious pests in Asian countries responsible for annual damages of 5-10% of rice crops (Pathak and Khan, 1994) [10]. Heavily infestation of rice stem borer may cause yield loss up to 80% (Rubia-Sanchez *et al*. 1997) [13]. Kakde and Patel (2014) [6] reported that yellow stem borer infestation appeared peak during first week of September (5.58 % DH) and 1st week of October (5.79 % WEH) in conventional method. YSB is the most destructive insect pests of rice crop (Mahar *et al.*, 1985) [9] and responsible for an annual yield loss of 10-15% with local catastrophic outbreaks causing up to 60% damage (Catling and Islam, 1981) [2]. The treatment of flubendiamide 20 WDG @175 gm/ha were recorded 4.40 % average infestation of stem borer and 1627 kg/ha average grain yield in semi deep water rice (Prasad *et al*, 2014) [12]. Chlorantraniliprole 25 SC a new insecticide found effective against major lepidopteran pests (Sidda Gowda, 2009) [14]. Karthikeyan (2018) [7] reported that the new insecticides, chlorantraniliprole @ 150 ml/ha, lufenuron 5.4 EC @ 600 ml/ha and fipronil 5% EC @ 1.50 l/ha were the most effective treatment against rice yellow stem borer,

Materials and Methods
The field experiment was laid out in randomized block

design during *kharif* 2014 – 15 to 2016-2017 with three replications at Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat, India. There were eight treatments including untreated control. The rice variety, GNR-3 was used for the experiment. The spacing was 20 X 15 cm whereas the gross plot size was 5.4 X 3.6 m^2 with the net plot size, 5.1 X 3.2 m^2. The crop was transplanted when the seedlings were 22 days old. All the recommended agronomic packages of practices were followed to raise the crop in good condition. The experiment was laid out in randomized block design (RBD) with eight treatments viz., T_1:chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre, T_2:thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre, T_3:flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre, T_4:lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre, T_5:fipronil 0.3 G @ 20 kg/ha T_6:cartap hydrochloride 4 G @ 20 kg/ha, T_7:carbofuran 3 G @ 25 kg/ha and T_8:control (Untreated).The treatments were applied at the time of pest appearance and the second spray of various insecticide treatments was given at 15 days after the first application of insecticides. The observations of rice stem borer were recorded before spray and 10 days after first and second spray, respectively. The yield data on grain and straw were recorded plot wise (kg per plot) and were converted as on hector basis. For yellow stem borers the population counts were taken on number of dead hearts at the time of pest appearance. Numbers of damaged tillers/10 hills were recorded from each plot before spray and 10 days after spray. First spray of insecticides was given at the time of pest appearance. Spraying of insecticide was carried out at evening time. Second spray of insecticides was given 30 days after First spray of insecticides. Grain and straw yield per plot in kilogram were recorded then both yields were calculated per hectare in each treatment. Stem borer damage recorded and percent incidence was calculated by using formula of Justin and Preetha, 2013. The per cent incidence (dead heart) was calculated as follows.

$$\text{Percent Incidence} = \frac{\text{Number of dead hearts}}{\text{Total number of tillers}} \text{X } 100$$

Results and Discussion

Effectiveness of Insecticides

The treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was found to be the best having less infestation of rice stem borer in first spray (2.50 % DH) and it was at par with chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (3.40 % DH) and thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (4.00 % DH) in first spray in the year 2014 (Table 1). As far as in second spray in same year, the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre was found to be the best having less infestation of rice stem borer (3.80 % DH) and it was at par with the treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre (3.90 % DH), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (4.90 % DH) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (5.50 % DH) in *kharif*-2014 (Table -1). Prasad *et al*, (2014) [12] reported that the treatment of flubendiamide 20 WDG @175 gm/ha were recorded 4.40 % average infestation of rice stem borer.

Whereas, chlorantraniliprole 25 SC a new insecticide found effective against major lepidopteran pests of rice including rice stem borer (Sidda Gowda, 2009) [14]. Karthikeyan (2018) [7] reported that the new insecticides, chlorantraniliprole @ 150 ml/ha was the most effective treatment against rice yellow stem borer. Thus, the present findings are in conformity with the earlier report.

The treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was found to be the best having less infestation of rice stem borer in first spray (1.70 % DH) and it was at par with chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (1.80 % DH) and thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (2.80 % DH) in first spray in *kharif*-2015 (Table 2). While remaining treatments were

* Figures outside the parenthesis are arcsine transformed value while figures in the parenthesis are re-transformed value Pound superior over control having less infestation of rice stem borer in first spray. As far as in second spray, the treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was found to be the best having less infestation of rice stem borer (2.10 % DH) and it was followed by the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (2.60 % DH), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (3.20 % DH) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (3.60 % DH) in *kharif*-2015 (Table 2). While the rest of treatments were found to be best having less infestation of rice stem borer except control in the year 2015.Insecticide flubendiamide 20 WDG @175 gm/ha was recorded 4.40 % average infestation of rice stem borer recorded by Prasad *et al*, (2014) [12]. The present findings are more or less in conformity with the earlier workers.

All treatments were found superior over control having less infestation of rice stem borer in first spray in the year 2016 **(**Table-3). The treatment of flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre was found to be the best having less infestation of rice stem borer in first spray (1.60 % DH) and it was at par with chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (3.10 % DH). The treatment of thiacloprid 21.7 SC 0.02 @ 10 ml/10 litres was found to be having less infestation of rice stem borer in first spray (4.10 % DH) and it was at par with the treatment of lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (5.00 % DH), fipronil 0.3 G @ 20 kg/ha (5.90 % DH), carbofuran 3 G @ 25 kg/ha (7.30 % DH) and cartap hydrochloride 4 G @ 20 kg/ha (8.20 % DH) in first spray in *kharif*-2016 (Table-3). Same result were found in second spray, the treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was found to be the best having less infestation of rice stem borer (4.50 % DH) and it was at par with the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (5.20 % DH), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (5.80 % DH) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (6.90 % DH) in *kharif*-2016 (Table-3) in the past reported by (Sidda Gowda, 2009) [14], Prasad *et al*, (2014) [12] and Karthikeyan (2018) [7]. Thus, the result obtained though present investigations are in agreement with earlier workers.

Table 1: Evaluation of insecticides against rice stem borer, *Scirpophaga* spp in paddy (2014)

Sr. No.	Treatments	Rate (g or ml/10 litre)	[First spray] % DH of stem borer		[Second spray] % DH of stem borer		Grain Yield (kg/plot)	Grain Yield (kg/ha)	Straw Yield (kg/plot)	Straw Yield (kg/ha)
			B. S.	10 DAS*	B.S.	10 DAS.*				
1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	3	10.17	10.54(3.40)	12.46	11.23 (3.80)	10.40	6373	11.43	7004
2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	10	11.91	11.59(4.00)	12.22	12.77 (4.90)	10.24	6275	11.63	7126
3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	2.5	10.68	9.06(2.50)	12.50	11.25(3.90)	10.65	6526	12.07	7396
4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	10	10.71	12.38(4.60)	12.58	13.53(5.50)	9.98	6115	11.27	6906
5	Fipronil 0.3 G @ 20 kg/ha	20 kg/ha	10.51	13.93(5.80)	12.40	14.83(6.50)	9.92	6078	11.07	6783
6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	20 kg/ha	11.78	17.36(8.90)	12.31	16.58(8.10)	9.47	5803	10.87	6661
7	Carbofuran 3 G @ 25 kg/ha (Check)	25 kg/ha	10.22	15.99(7.60)	12.02	15.87(7.50)	9.75	5974	11.27	6906
8	Control (Untreated)	-	11.85	22.97(15.20)	15.22	25.93(19.10)	8.05	4933	9.27	5680
	SEm±		1.10	1.06	0.64	0.91	0.31	-	0.28	-
	C.D. at 5 %		NS	3.21	NS	2.76	0.94	-	0.86	-
	C.V. %		17.39	12.88	8.81	10.32	5.49	-	4.42	-

Where, DAS=Days after spray. BS= Before spray

* Figures outside the parenthesis are arcsine transformed value while figures in the parenthesis are re-transformed value.

Table 2: Evaluation of insecticides against rice stem borer, *Scirpophaga* spp in paddy (2015)

Sr. No.	Treatments	Rate (gor ml/10 litre)	[First spray] % DH of stem borer		[Second spray] % DH of stem borer		Grain Yield (kg/plot)	Grain Yield (kg/ha)	Straw Yield (kg/plot)	Straw Yield (kg/ha)
			B. S.	10 DAS*	B.S.	10 DAS.*				
1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	3	5.48	7.68 (1.80)	7.35	9.24 (2.60)	10.63	6513	11.87	7273
2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	10	5.51	9.56 (2.80)	7.58	10.35 (3.20)	10.33	6330	11.50	7047
3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	2.5	5.72	7.40 (1.70)	7.61	8.24 (2.10)	11.03	6759	12.33	7555
4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	10	5.67	9.98 (3.00)	7.38	10.99 (3.60)	10.23	6268	11.13	6820
5	Fipronil 0.3 G @ 20 kg/ha	20 kg/ha	6.01	11.12 (3.70)	7.78	11.55 (4.00)	10.05	6158	10.05	6158
6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	20 kg/ha	5.98	12.06 (4.30)	7.67	13.24 (5.20)	9.60	5882	11.03	6759
7	Carbofuran 3 G @ 25 kg/ha (Check)	25 kg/ha	5.73	11.40 (3.90)	7.52	11.98 (5.10)	9.83	6023	11.20	6863
8	Control (Untreated)	-	5.92	15.71 (7.30)	8.45	17.51 (9.10)	8.33	5104	9.33	5717
	SEm±		0.29	0.62	0.24	0.30	0.27	-	0.29	-
	C.D. at 5 %		NS	1.86	NS	0.91	0.81	-	0.87	-
	C.V. %		8.72	10.05	5.50	4.48	4.61	-	4.48	-

Where, DAS=Days after spray. BS= Before spray

Table 3: Evaluation of insecticides against rice stem borer, *Scirpophaga* spp in paddy (2016)

Sr. No.	Treatments	Rate (g or ml/10 litre)	[First spray] % DH of stem borer		[Second spray] % DH of stem borer		Grain Yield (kg/plot)	Grain Yield (kg/ha)	Straw Yield (kg/plot)	Straw Yield (kg/ha)
			B. S.	10 DAS*	B.S.	10 DAS*				
1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	3	10.53	10.13(3.10)	13.79	13.14(5.20)	7.96	4875	10.33	6332
2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	10	10.25	11.49(4.10)	15.15	13.99(5.80)	7.74	4741	10.03	6148
3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	2.5	11.50	7.14 (1.60)	12.96	12.29(4.50)	8.40	5145	10.60	6495
4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	10	11.79	12.96(5.00)	13.10	15.25(6.90)	7.51	4600	9.70	5944
5	Fipronil 0.3 G @ 20 kg/ha	20 kg/ha	12.05	14.05(5.90)	14.04	16.31(7.90)	7.26	4449	9.40	5760
6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	20 kg/ha	10.49	16.63(8.20)	11.84	17.68(9.20)	6.76	4142	9.00	5515

7	Carbofuran 3 G @ 25 kg/ha (Check)	25 kg/ha	10.78	15.68(7.30)	11.28	17.12(8.70)	6.97	4271	9.17	5617
8	Control (Untreated)	-	12.19	22.85(15.10)	15.34	25.12(18.00)	6.48	3973	8.80	5392
	SEm ±		1.14	1.41	0.98	1.12	0.04	-	0.07	-
	C.D. at 5 %		NS	4.23	NS	3.40	0.14	-	0.22	-
	C.V. %		17.72	17.58	12.68	11.85	1.06	-	1.31	-

Where, DAS=Days after spray. BS= Before spray

* Figures outside the parenthesis are arcsine transformed value while figures in the parenthesis are re-transformed value.

Table 4: Evaluation of insecticides against rice stem borer, *Scirpophaga* spp in paddy in first spray (Pooled)

Sr. No.	Treatments	Before spray (BS) % DH of stem borer				[First spray] % DH of stem borer (10 DAS)*			
		2014	2015	2016	Pooled	2014	2015	2016	Pooled
T_1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	10.17	5.48	10.53	8.73	10.54 (3.40)	7.68(1.80)	10.13(3.10)	9.45 (2.70)
T_2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	11.91	5.51	10.25	9.22	11.59(4.00)	9.56(2.80)	11.49(4.10)	10.88 (3.60)
T_3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	10.68	5.72	11.50	9.30	9.06(2.50)	7.40(1.70)	7.14(1.60)	7.87 (1.90)
T_4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	10.71	5.67	11.79	9.39	12.38(4.60)	9.98(3.00)	12.96(5.00)	11.77 (4.20)
T_5	Fipronil 0.3 G @ 20 kg/ha	10.51	6.01	12.05	9.52	13.93(5.80)	11.12(3.70)	14.05(5.90)	13.04 5.10)
T_6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	11.78	5.98	10.49	9.41	17.36(8.90)	12.06(4.30)	16.63(8.20)	15.35(7.00)
T_7	Carbofuran 3 G @ 25 kg/ha (Check)	10.22	5.73	10.78	8.91	15.99(7.60)	11.40(3.90)	15.68(7.30)	14.36 (6.10)
T_8	Control (Untreated)	11.85	5.92	12.19	9.99	22.97(15.20)	15.71(7.30)	22.85(15.10)	20.51(12.30)
	SEm ±	1.10	0.29	1.14	0.49	1.06	0.62	1.41	0.64
	C.D. at 5%	NS	NS	NS	NS	3.21	1.86	4.23	1.82
	C.V. %	17.39	8.72	17.72	-	12.88	10.05	17.58	-
	Y x T SEm ±				0.93				1.08
	C.D. at 5%				NS				NS
	C.V. %				17.36				14.45

Where, DAS=Days after spray. BS= before spray

* Figures outside the parenthesis are arc sine transformed value while figures in the parenthesis are re-transformed value.

Table 5: Evaluation of insecticides against rice stem borer, *Scirpophaga* spp in second spray (Pooled)

Sr. No.	Treatments	Before spray (BS) % DH of stem borer				[Second spray] % DH of stem borer (10 DAS)*			
		2014	2015	2016	Pooled	2014	2015	2016	Pooled
T_1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	12.46	7.35	13.79	11.20	11.23(3.80)	9.24(2.60)	13.14(5.20)	11.20 (3.80)
T_2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	12.22	7.58	15.15	11.65	12.77(4.90)	10.35(3.20)	13.99(5.80)	12.43 (4.60)
T_3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	12.50	7.61	12.96	11.02	11.25(3.80)	8.24(2.10)	12.29(4.50)	10.59 (3.40)
T_4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	12.58	7.38	13.10	11.02	13.53(5.50)	10.99(3.60)	15.25(6.90)	13.26 (5.30)
T_5	Fipronil 0.3 G @ 20 kg/ha	12.40	7.78	14.04	11.41	14.83(6.50)	11.55(4.00)	16.31(7.90)	14.23 (6.00)
T_6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	12.31	7.67	11.84	10.27	16.58(8.10)	13.24(5.20)	17.68(9.20)	15.83 (7.40)
T_7	Carbofuran 3 G @ 25 kg/ha (Check)	12.02	7.52	11.28	13.00	15.87(7.50)	11.98(5.10)	17.12(8.70)	14.99 (6.70)
T_8	Control (Untreated)	15.22	8.45	15.34	11.41	25.93(19.10)	17.51(9.10)	25.12(18.00)	22.86 (15.10)
	SEm ±	0.64	0.24	0.98	0.42	0.91	0.30	1.12	0.52
	C.D. at 5%	NS	NS	NS	1.16	2.76	0.91	3.40	1.47
	C.V. %	8.81	5.50	12.68	-	10.32	4.48	11.85	-
	Y x T SEm ±				0.69				0.86
	C.D. at 5%				NS				NS
	C.V. %				10.67				10.21

Where, DAS=Days after spray. BS= Before spray

Table 6: The effect of insecticides on yield parameters of rice (Pooled)

Sr. No.	Treatments	Grain yield (kg/plot)				Grain yield (kg/ha)	Straw yield (kg/plot)				Straw yield (kg/ha)
		2014	2015	2016	Pooled		2014	2015	2016	Pooled	
T_1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	10.40	10.63	7.96	9.66	5919	11.43	11.87	10.33	11.21	6869
T_2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	10.24	10.33	7.74	9.44	5784	11.63	11.50	10.03	11.06	6777
T_3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	10.65	11.03	8.40	10.03	6146	12.07	12.33	10.60	11.67	7151
T_4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	9.98	10.23	7.51	9.24	5662	11.27	11.13	9.70	10.70	6556
T_5	Fipronil 0.3 G @ 20 kg/ha	9.92	10.05	7.26	9.08	5564	11.07	10.05	9.40	10.17	6232
T_6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	9.47	9.60	6.76	8.61	5276	10.87	11.03	9.00	10.30	6311
T_7	Carbofuran 3 G @ 25 kg/ha (Check)	9.75	9.83	6.97	8.86	5429	11.27	11.20	9.17	10.54	6458
T_8	Control (Untreated)	8.05	8.33	6.48	7.62	4669	9.27	9.33	8.80	9.13	5594
	SEm ±	0.31	0.27	0.04	0.13	-	0.28	0.29	0.07	0.16	-
	C.D. at 5%	0.94	0.81	0.14	0.38	-	0.86	0.87	0.22	0.44	-
	C.V. %	5.49	4.61	1.06	-	-	4.42	4.48	1.31	-	-
	Y x T SEm ±				0.24	-				0.24	-
	C.D. at 5%				NS	-				NS	-
	C.V. %				4.54	-				3.86	-

Table 7: Economics of insecticides to control rice stem borer, *Scirpophaga* spp.

Sr. No	Name of Fungicides	Total Spray	Quantity ml or g./ha	Cost (Rs./ha)	Labour cost (Rs/ha)	Pesticides cost (Rs./ ha)	Total cost (Rs/ha)	Yield (Kg/ ha)		Income (Rs/ha)		Gross Income (Rs/ha)	Net Income (Rs/ha	Increase Over control	BCR
								Grain	Straw	Grain	Straw				
T_1	Chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre	2	150	2700	356	3056	33556	5919	6869	82866	20607	103473	69917	20269	1:2.08
T_2	Thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre	2	500	2500	356	2856	33356	5784	6777	80976	20331	101307	67951	18303	1:2.04
T_3	Flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre	2	125	288	356	644	31144	6146	7151	86044	21453	107497	76353	26705	1:2.45
T_4	Lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre	2	500	425	356	781	31281	5662	6556	79268	19668	98936	67655	18007	1:2.16
T_5	Fipronil 0.3 G @ 20 kg/ha	2	20 kg	2000	356	2356	32856	5564	6232	77896	18696	96592	63736	14088	1:1.94
T_6	Cartap hydrochloride 4 G @ 20 kg/ha (Check)	2	20 kg	3000	356	3356	33856	5276	6311	73864	18933	92797	58941	9293	1:1.74
T_7	Carbofuran 3 G @ 25 kg/ha (Check)	2	25 kg	2500	356	2856	33356	5429	6458	76006	19374	95380	62024	12376	1:1.86
T_8	Control (Untreated)	0	0	0	0	0	32500	4669	5594	65366	16782	82148	49648	0	1:1.53

Cost of Pesticides

1. Chlorantraniliprole 18.5 SC — Rs. 9000/500 ml
2. Thiacloprid 21.7 SC — Rs.2500/500 ml
3. Flubendiamide 20 WG — Rs.1150/500 g
4. Lambda cyhalothrin 2.5 EC — Rs. 425/500 ml
5. Fipronil 0.3 G — Rs. 50/500 g
6. Cartap hydrochloride 4 G — Rs. 75/500 g
7. Carbofuran 3 G — Rs. 50/500 g

Labour cost: Rs. 178/day
Grain: Rs. 14.00/ kg
Straw: Rs. 3.00/ kg

Overall in pooled data (2014, 2015 and 2016) in Table - 4 the result indicated that in first spray, infestation of rice stem borer/hill at 10 DAS in the treatment of flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre was found to be the best having less infestation of rice stem borer (1.90 % DH) and it was followed by the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (2.70 % DH), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (3.60 % DH) and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (4.20 % DH) and fipronil 0.3 G @ 20 kg/ha (5.10 % DH) (Table-4). But in second spray, the treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was found to be the best having less infestation of rice stem borer (3.40 % DH) and it was at par with the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (3.80 % DH (Table-5). Insecticide flubendiamide 20 WDG @175 gm/ha was recorded 4.40 % average infestation of rice stem borer reported by Prasad *et al*, (2014) [12]. The present studies were also more supported by (Sidda Gowda, 2009) [14].

* Figures outside the parenthesis are arcsine transformed value while figures in the parenthesis are re-transformed value. Karthikeyan (2018) [7] reported that the new insecticides, chlorantraniliprole @ 150 ml/ha was the most effective treatment against rice yellow stem borer. Thus, the present findings are in agreement with the earlier report.

Grain and straw yield

The results on grain and straw yield of paddy were affected by different treatments recorded and indicated in Table - 6. The result indicated that the effect of different treatments was found to be significant during all the individual years as well in pooled result. All the treatments were found significantly superior over control for grain and straw yield of paddy during 2014, 2015 and 2016. On the basis of grain yield, treatment of flubendiamide 20 WG 0.005 @ 2.5 gm /10 litre was recorded the highest grain yield (6146 kg/ha) and it was followed by the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (5919 kg/ha), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (5784 kg/ha), lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (5662 kg/ha) and fipronil 0.3 G @ 2.5 kg/ha (5564 Kg/ha) (Table-6). Prasad *et al*, (2014) [12] reported that flubendiamide 20 WDG @175 gm/ha were recorded 1627 kg/ha average grain yield in semi deep water rice. Thus, the present findings are not in agreement with the earlier report. Whereas remaining treatments superior over control. For considering straw yield, treatment of flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre was found the highest straw yield (7151 kg/ha) and it was followed by the treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre (6899 kg/ha), thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre (6777 kg/ha), lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre (6556 kg/ha) and carbofuran 3 G @ 25 kg/ha (6458 kg/ha). While, remaining treatments were found superior over control (Table 6).

Economics

The economics is calculated by considering the profit increase over control of different treatments (Table-7).The treatment of flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre registered higher net income (Rs.76353/ha) and BCR (1:2.45) followed by treatment of chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 litre with net income (Rs. 69917/ha) and BCR 1:2.08. However, the treatment of thiacloprid 21.7 SC 0.02 @ 10 ml/10 litre and lambda cyhalothrin 2.5 EC 0.0025 @ 10 ml/10 litre and remaining treatments recorded less yield than flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre and chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 liter.Therefore, considering consistent efficacy, yield and economics of treatments flubendiamide 20 WG 0.005 @ 2.5 gm/10 litre or chlorantraniliprole 18.5 SC 0.006 @ 3 ml/10 liter are recommended to manage rice stem borer and to produce more yield of rice in South Gujarat (Table-7).

Conclusion

The paddy growers of South Gujarat agro-climate zone are advised to apply two sprays of flubendiamide 20 WG 0.005 (2.5 gm/10 litre) or chlorantraniliprole 18.5 SC 0.006 (3 ml/10 litre) for effective management of rice stem borer and to harvest higher grain and straw yield. The first spray should be given when pest appearance and the remaining one spray at 15 days after first spray.

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