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BIO-EFFICACY OF INSECTICIDES AGAINST RICE YELLOW STEMBORER AND LEAF FOLDER

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ABSTRACT

The experiment was conducted to test the bio-efficacy of insecticides against rice yellow stemborer and leaf folder at Main Rice Research Station, Anand Agricultural University, Nawagam during *kharif* 2019 and 2020 crop seasons. The experiment comprising seven treatments was laid out in randomized block design with three replications. The lowest per cent dead hearts and white earheads (3.76 and 8.91/hill) due to yellow stemborer were recorded in the plot treated with the chlorantraniliprole 18.5 SC (30 g a.i./ha) and it was at par with the cartap hydrochloride 75 SG (375 g a.i./ha) (4.0 and 10.08/hill) and flubendiamide 4 + buprofezin 20 SC (210 g a.i./ha) (4.16 and 9.10/hill). Similar trend was recorded with the infestation of leaf folder. The highest grain and straw yield (51.52 and 77.54 q/ha) was recorded from the plots treated with chlorantraniliprole 18.5 SC and it was at par with the cartap hydrochloride 75 SG (50.87 and 76.13 q/ha) and flubendiamide 4 + buprofezin 20 SC (49.28 and 74.92 q/ha). The results revealed that the chlorantraniliprole 18.5 SC, cartap hydrochloride 75 SG, and flubendiamide 4 + buprofezin 20 SC were found superior in management of yellow stemborer and leaf folder.

Keywords: Insecticides, Leaf folder, Yellow stemborer, Yield.

Rice (*Oryza sativa* L.) is an important staple food crop of Asia and a primary staple diet of over half of the world population. Among the rice growing countries, India has the largest area under rice in the world *i.e.* about 43.66 million ha and production 118.87 million tonnes, whereas productivity was 2722 kg per hectare during 2019-20 (Anonymous, 2021). In the year 2019-20, Gujarat had area under rice cultivation about 0.90 million hectare and production was 1.98 million tonnes with average productivity of 2192 kg/ha (Anonymous, 2020b).

The two major factors responsible for poor yield are adverse weather and pest epidemic. Among the various biological constraints, insect-pest problem is one of the major constraints accounting for 50% damage at vegetative, 30% at reproductive and 20% at ripening stage of rice (Gupta and Raghuraman, 2003). Pathak and Dhaliwal (1981) reported that due to insect-pests attack the average yield reduction in rice is 40%. About 21 per cent of the global production of is lost to insect-pests (Yarasi *et al.,* 2008). In rice ecosystem, about 100 insects were recorded as pests, of them 20 are designated as major pests (Pathak and Dhaliwal, 1981).

Among the insect-pests, yellow stemborer (YSB), *Scirpophaga incertulas* (Walker) is the most important and devastating pest of rice ecosystem that causes yield losses up to 27-34% every year (Prasad *et al.,* 1988). The damage is caused by larvae, which bore into the stem and destroy the growing tips by feeding the internal contents. This in turn disrupts the flow of water and nourishment to the plant, thereby causing dead hearts (DH) during vegetative stage. When the infestation occurs at the flowering stage, the ear heads become chaffy called white ears (WE) (Jadhao and Khurad, 2012).

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) was considered as minor pest earlier but now a days it has become a major pest in many parts of the world (Ahmed *et al.,* 2010). The young larvae of the leaf folder feed on open leaves but later feed on the green mesophyll tissue inside the rolled leaf formed by folding the leaf longitudinally with a sticky substance. The scraped leaves become membranous, turn whitish in colour that is visible from a distance in the rice field. A single larva can damage a number of leaves. This activity disturbs the photosynthesis, plant growth and ultimately yield may reduce.

For quick knock down effect, the application of judicious dose of insecticides is desired to save the crop from both the insect-pests. Seni *et al.* (2017) reported that flubendiamide + buprofezin 24 SC led to less dead hearts and white earheads. Suri and Makkar (2016) confirmed that cartap hydrochloride 75 SG at 318.7 g a.i./ha to be highly effective against rice stemborers and leaf folder. Karthikeyan (2017) revealed that the chlorantraniliprole 18.5 SC at 150 ml/ha was found most effective against yellow stemborer and leaf folder. Besides, rendering effective control of target-pests, the new insecticides must be cost effective, safer to natural

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enemies and other non-target organisms. Hence, the present study was carried out on bio-efficacy of insecticides against yellow stemborer and leaf folder in rice.

MATERIALS AND METHODS

The experiment was carried out under field condition at Main Rice Research Station, Anand Agricultural University, Nawagam, Gujarat during *kharif* 2019 and 2020. The thirty day old seedlings of rice variety GR 11 were transplanted to main field with spacing of 20 × 15 cm in the 4.5 × 3.0 m size plot. The rice crop was raised by following the recommended agronomical practices. The experiment was laid out in randomized block design using three replications of seven treatments *viz*., cartap hydrochloride 75 SG (375 g a.i./ha, 10 ml per 10 liter of water), flubendiamide 4 + buprofezin 20 SC (210 g a.i./ha, 17.5 ml per 10 liter of water), chlorantraniliprole 18.5 SC (30 g a.i./ha, 3 ml per 10 liter of water), lambda-cyhalothrin 5 EC (12.5 g a.i./ha, 5 ml per 10 liter of water), carbosulfan 25 EC (250 g a.i./ha, 20 ml per 10 liter of water), bifenthrin 10 EC (50 g a.i./ha, 10 ml per 10 liter of water) and untreated control (water spray). The spray solution used was 500 litre per hectare. First spray was applied when the insect-pests population initiated (the economic threshold level for stem borer was 10% DH and for leaf folder two fully damaged leaves per hill) and second spray was applied after 15 days of first spray using knapsack sprayer to manage the remaining population of both the insect-pests. Observations on dead hearts (DH) and damaged leaves (DL) were recorded before first spray, 7, 10 and 14 days after each spray and WE at 15 days before harvest from five randomly selected hills in each treatment. Then percent dead hearts, white earheads and damaged leaves were calculated by formula *i.e.* dead hearts or white earheads or damaged leaves (%) = (number of dead hearts or white earheads or damaged leaves / total tillers or panicle bearing tillers or total leaves) × 100.

The crop was harvested at maturity and grain as well as straw yield was recorded separately from net plot area of each treatment. The data on per cent dead hearts, white earheads, damaged leaves, grain and straw yield were subjected to ANOVA.

RESULTS AND DISCUSSION

Yellow stemborer

The mean data revealed that chlorantraniliprole 18.5 SC (30 g a.i./ha) was found most effective in suppression of yellow stemborer infestation in terms of per cent dead hearts (3.16 and 4.41/hill) followed by cartap hydrochloride 75 SG, 375 g a.i./ha (3.15 and 4.93/hill) and flubendiamide 4 + buprofezin 20 SC, 210 g a.i./ha (3.09 and 5.39/hill) in the year 2019 and 2020, respectively. The next effective treatments were bifenthrin 10 EC, 50 g a.i./ha, lambda-cyhalothrin 5 EC, 12.5 g a.i./ha and carbosulfan 25 EC, 250 g a.i./ha where the per cent dead hearts was recorded 6.37 and 10.29, 6.48 and 10.23 and 6.63 and 10.32 in the year 2019 and 2020, respectively.

Based on the results of per cent white earheads at pre harvest revealed that among all the treatments chlorantraniliprole 18.5 SC, 30 g a.i./ha recorded minimum per cent white earheads (9.84 and 7.99/hill) which was at par with the flubendiamide 4 + buprofezin 20 SC, 210.0 g a.i./ha (8.69 and 9.50/hill) and cartap hydrochloride 75 SG, 375 g a.i./ha (10.33 and 9.84/hill) in the year 2019 and 2020, respectively.

Pooled over years

The result of pooled over two years exhibited that the lowest per cent dead hearts (3.76/hill) was in the plot treated with the chlorantraniliprole 18.5 SC (30 g a.i./ha) and it was at par with the cartap hydrochloride 75 SG (375 g a.i./ha) (4.0/hill) and flubendiamide 4 + buprofezin 20 SC (210 g a.i./ha) (4.16/hill). Among the evaluated insecticides, the highest dead hearts (8.22/hill) were observed in bifenthrin 10 EC, 50 g a.i./ha followed by lambda-cyhalothrin 5 EC, 12.5 g a.i./ha (8.26/hill) and carbosulfan 25 EC, 250 g a.i./ha (8.38/hill). Similar trend of insecticide efficacy was observed for per cent white earheads.

The present findings are similar with the earlier findings. Prasad *et al*. (2014), Seni *et al*. (2017) and Maji *et al.* (2017) reported that the combination of flubendiamide + buprofezin 24 SC recorded less dead hearts and white earheads damaged by stemborer in rice. Suri and Makkar (2016) confirmed that cartap hydrochloride 75 SG at 318.7 g a.i./ha to be highly effective against rice stemborers. Seni and Naik (2017), Omprakash *et al.* (2017), Reddy *et al.* (2019) and Kinjale *et al*. (2021) revealed that the chlorantraniliprole 20 SC, 30 g a.i/ha treated plot recorded significantly lower per cent of dead hearts and white earheads caused by stemborer in rice.

Leaf folder

The results revealed that the lowest per cent damaged leaves (11.46 and 4.78/hill) were found in plot treated with chlorantraniliprole 18.5 SC, 30 g a.i./ha and it was at par with cartap hydrochloride 75 SG, 375 g a.i./ha (11.45 and 5.28/hill) and flubendiamide 4 + buprofezin 20 SC, 210.0 g a.i./ha (11.49 and 5.55/hill) in the year 2019 and 2020, respectively. Lambda-cyhalothrin 5 EC, 12.5 g a.i./ha (17.05 and 10.46), bifenthrin 10 EC, 50 g a.i./ha (18.13 and 10.09) and

Table 1. Efficacy of different insecticides against yellow stemborer of rice (*Kharif* 2019 and 2020)

Tr. No.	Treatments	Dose (g a.i./ha)	Dead hearts (%)									White earheads (%)		
			2019				2020				Pooled over year			
			Before spray	1st spray	2nd spray	Pooled over sprays	Before spray	1st spray	2nd spray	Pooled over sprays		2019	2020	Pooled over year
1	Cartap hydrochloride 75 SG, 0.075%	375.0	8.58 (2.23)	8.55[a] (2.21)	11.90[a] (4.25)	10.23[a] (3.15)	24.50 (17.19)	14.53[a] (6.29)	11.14[a] (3.73)	12.84[a] (4.93)	11.53[a] (4.00)	18.75[a] (10.33)	18.28[a] (9.84)	18.51[a] (10.08)
2	Flubendiamide 4 + buprofezin 20 SC, 0.042%	210.0	9.17 (2.54)	8.53[a] (2.20)	11.71[a] (4.12)	10.12[a] (3.09)	24.99 (17.84)	14.99[a] (6.69)	11.87[a] (4.23)	13.43[a] (5.39)	11.77[a] (4.16)	17.15[a] (8.69)	17.95[a] (9.50)	17.55[a] (9.10)
3	Chlorantraniliprole 18.5 SC, 0.006%	30.0	9.11 (2.51)	8.80[a] (2.34)	11.68[a] (4.10)	10.24[a] (3.16)	23.94 (16.47)	13.91[a] (5.78)	10.33[a] (3.21)	12.12[a] (4.41)	11.18[a] (3.76)	18.28[a] (9.84)	16.42[a] (7.99)	17.37[a] (8.91)
4	Lambda-cyhalothrin 5EC, 0.0025%	12.5	9.83 (2.91)	13.63[b] (5.56)	15.86[b] (7.47)	14.75[b] (6.48)	23.88 (16.38)	19.88[b] (11.56)	17.43[b] (8.98)	18.66[b] (10.23)	16.70[b] (8.26)	29.77[b] (24.65)	24.75[b] (17.52)	27.34[b] (21.09)
5	Carbosulfan 25 EC, 0.05%	250.0	8.92 (2.40)	13.54[b] (5.49)	16.29[b] (7.86)	14.92[b] (6.63)	23.87 (16.37)	19.84[b] (11.52)	17.64[b] (9.18)	18.74[b] (10.32)	16.83[b] (8.38)	31.39[b] (27.13)	29.42[b] (24.12)	30.41[b] (25.63)
6	Bifenthrin 10 EC, 0.01%	50.0	9.85 (2.93)	13.19[b] (5.21)	16.04[b] (7.63)	14.62[b] (6.37)	23.73 (16.19)	20.42[b] (12.18)	17.00[b] (8.55)	18.71[b] (10.29)	16.66[b] (8.22)	33.17[b] (29.93)	25.16[b] (18.07)	29.33[b] (24.00)
7	Untreated	-	10.65 (3.42)	17.25[c] (8.79)	23.43[c] (15.82)	20.34[c] (12.08)	24.89 (17.71)	25.60[c] (18.67)	25.36[c] (18.34)	25.48[c] (18.51)	22.91[c] (15.16)	44.65[c] (49.39)	39.59[c] (40.61)	42.13[c] (45.00)
	Treatment (T)		0.75	0.412	0.384	0.280	1.77	0.781	0.721	0.535	0.543	2.450	1.720	1.511
	Spray (S)		-	-	-	0.149	-	-	-	0.286	2.121	-	-	-
	Year (Y)		-	-	-	-	-	-	-	-	0.161	-	-	-
S.Em	T x S		-	-	-	0.395	-	-	-	0.757	0.427	-	-	-
	T x Y		-	-	-	-	-	-	-	-	0.427	-	-	-
	Y x S		-	-	-	-	-	-	-	-	0.228	-	-	-
	T x S x Y		-	-	-	-	-	-	-	-	0.604	-	-	-
CD at 5 %			NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)			13.90	10.40	7.55	8.75	12.66	12.75	13.75	13.33	11.84	15.49	12.15	14.13

Figures in parenthesis are retransformed values and those outsides are arcsine transformed values;
Treatment means with the letter(s) in common do not differ significantly by DNMRT at 5% level of significance;
Significant parameters and its interactions: T, P, S and T × S; NS- Non significant, Sig.-Significant

Table 2. Efficacy of different insecticides against leaf folder of rice (*Kharif* 2019 and 2020)

Tr. No.	Treatments	Dose (g a.i./ha)	Damaged leaves (%)								
			2019				2020				Pooled over year
			Before spray	1st spray	2nd spray	Pooled over sprays	Before spray	1st spray	2nd spray	Pooled over sprays	
1	Cartap hydrochloride 75 SG, 0.075%	375.0	16.51 (8.08)	17.44^{a} (8.98)	22.11^{a} (14.17)	19.78^{a} (11.45)	15.12 (6.81)	11.86^{a} (4.23)	14.70^{a} (6.44)	13.28^{a} (5.28)	16.53^{a} (8.09)
2	Flubendiamide 4 + buprofezin 20 SC, 0.042%	210.0	15.93 (7.53)	17.49^{a} (9.03)	22.13^{a} (14.20)	19.81^{a} (11.49)	15.19 (6.87)	12.17^{a} (4.44)	15.07^{a} (6.76)	13.62^{a} (5.55)	16.72^{a} (8.27)
3	Chlorantraniliprole 18.5 SC, 0.006%	30.0	16.66 (8.22)	17.82^{a} (9.36)	21.76^{a} (13.74)	19.79^{a} (11.46)	15.17 (6.85)	11.25^{a} (3.81)	14.02^{a} (5.87)	12.64^{a} (4.78)	16.21^{a} (7.79)
4	Lambda-cyhalothrin 5EC, 0.0025%	12.5	16.18 (7.77)	21.36^{b} (13.26)	27.41^{b} (21.20)	24.39^{b} (17.05)	14.70 (6.44)	15.73^{b} (7.35)	22.02^{b} (14.05)	18.87^{bc} (10.46)	21.63^{b} (13.59)
5	Carbosulfan 25 EC, 0.05%	250.0	15.90 (7.51)	22.17^{b} (14.23)	28.27^{b} (22.43)	25.22^{b} (18.15)	14.60 (6.35)	17.07^{b} (8.62)	24.31^{b} (16.95)	20.69^{c} (12.48)	22.95^{b} (15.21)
6	Bifenthrin 10 EC, 0.01%	50.0	15.93 (7.53)	22.08^{b} (14.13)	28.32^{b} (22.50)	25.20^{b} (18.13)	15.40 (7.05)	15.70^{b} (7.32)	21.34^{b} (13.25)	18.52^{b} (10.09)	21.86^{b} (13.86)
7	Untreated	-	16.93 (8.48)	25.88^{c} (19.06)	35.19^{c} (33.21)	30.54^{c} (25.82)	15.16 (6.84)	21.70^{c} (13.67)	31.59^{c} (27.43)	26.64^{d} (20.11)	28.59^{c} (22.90)
	T		0.720	0.692	0.494	0.425	0.952	0.736	1.004	0.617	0.592
	S		-	-	-	0.227	-	-	-	0.330	0.200
	Y		-	-	-	-	-	-	-	-	0.200
S.Em.±	T x S		-	-	-	0.601	-	-	-	0.872	0.530
	T x Y		-	-	-	-	-	-	-	-	0.530
	Y x S		-	-	-	-	-	-	-	-	0.283
	T x S x Y		-	-	-	-	-	-	-	-	0.749
CD at 5 %			NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.	Sig.
C.V. (%)			7.66	10.11	5.61	7.68	11.04	14.75	14.81	14.83	10.93

Figures in parenthesis are retransformed values and those outsides are arcsine transformed values;
Treatment means with the letter(s) in common do not differ significantly by DNMRT at 5% level of significance

Table 3. Impact of insecticides on grain and straw yield of rice (*Kharif* 2019 and 2020)

Tr. No.	Treatments	Dose (g a.i./ ha)	Dead hearts (%)			White earheads (%)			Damaged leaves (%)			Yield (q/ha)					
												Grain			Straw		
			2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
1	Cartap hydrochloride 75 SG, 0.075%	375.0	10.23^{a} (3.15)	12.84^{a} (4.93)	11.53^{a} (4.00)	18.75^{a} (10.33)	18.28^{a} (9.84)	18.51^{a} (10.08)	19.78^{a} (11.45)	13.28^{a} (5.28)	16.53^{a} (8.09)	47.70^{a}	54.04^{b}	50.87^{a}	71.67^{a}	80.59^{a}	76.13^{a}
2	Flubendiamide 4 + buprofezin 20 SC, 0.042%	210.0	10.12^{a} (3.09)	13.43^{a} (5.39)	11.77^{a} (4.16)	17.15^{a} (8.69)	17.95^{a} (9.50)	17.55^{a} (9.10)	19.81^{a} (11.49)	13.62^{a} (5.55)	16.72^{a} (8.27)	48.03^{a}	50.52^{b}	49.28^{a}	72.00^{a}	77.84^{a}	74.92^{a}
3	Chlorantraniliprole 18.5 SC, 0.006%	30.0	10.24^{a} (3.16)	12.12^{a} (4.41)	11.18^{a} (3.76)	18.28^{a} (9.84)	16.42^{a} (7.99)	17.37^{a} (8.91)	19.79^{a} (11.46)	12.64^{a} (4.78)	16.21^{a} (7.79)	47.00^{a}	56.04^{a}	51.52^{a}	70.83^{a}	84.25^{a}	77.54^{a}
4	Lambda-cyhalothrin 5EC, 0.0025%	12.5	14.75^{b} (6.48)	18.66^{b} (10.23)	16.70^{b} (8.26)	29.77^{b} (24.65)	24.75^{b} (17.52)	27.34^{b} (21.09)	24.39^{b} (17.05)	18.87^{bc} (10.46)	21.63^{b} (13.59)	37.93^{b}	45.83^{cd}	41.88^{b}	57.00^{b}	70.82^{b}	63.91^{b}
5	Carbosulfan 25 EC, 0.05%	250.0	14.92^{b} (6.63)	18.74^{b} (10.32)	16.83^{b} (8.38)	31.39^{b} (27.13)	29.42^{b} (24.12)	30.41^{b} (25.63)	25.22^{b} (18.15)	20.69^{c} (12.48)	22.95^{b} (15.21)	35.07^{b}	38.90^{de}	36.98^{bc}	52.17^{b}	72.04^{b}	62.10^{b}
6	Bifenthrin 10 EC, 0.01%	50.0	14.62^{b} (6.37)	18.71^{b} (10.29)	16.66^{b} (8.22)	33.17^{b} (29.93)	25.16^{b} (18.07)	29.33^{b} (24.00)	25.20^{b} (18.13)	18.52^{b} (10.09)	21.86^{b} (13.86)	34.37^{b}	44.13^{c}	39.25^{b}	51.00^{b}	71.43^{b}	61.21^{b}
7	Untreated	-	20.34^{c} (12.08)	25.48^{c} (18.51)	22.91^{c} (15.16)	44.65^{c} (49.39)	39.59^{c} (40.61)	42.13^{c} (45.00)	30.54^{c} (25.82)	26.64^{d} (20.11)	28.59^{c} (22.90)	25.90^{c}	34.15^{e}	30.02^{c}	38.83^{c}	53.42^{b}	46.13^{c}
	T		0.280	0.535	0.543	2.450	1.720	1.511	0.425	0.617	0.592	1.83	2.952	1.540	2.86	3.129	1.854
	S		0.149	0.286	2.121	-	-	-	0.227	0.330	0.200	-	-	-	-	-	-
	Y		-	-	0.161	-	-	-	-	-	0.200	-	-	0.770	-	-	0.927
S.Em.±	T x S		0.395	0.757	0.427	-	-	-	0.601	0.872	0.530	-	-	-	-	-	-
	T x Y		-	-	0.427	-	-	-	-	-	0.530	-	-	2.667	-	-	3.212
	Y x S		-	-	0.228	-	-	-	-	-	0.283	-	-	-	-	-	-
	T x S x Y		-	-	0.604	-	-	-	-	-	0.749	-	-	-	-	-	-
CD at 5 %			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)			8.75	13.33	11.84	15.49	12.15	14.13	7.68	14.83	10.93	8.05	11.06	10.78	8.38	7.43	8.43

Figures in parenthesis are retransformed values and those outsides are arcsine transformed values;
Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance;
Significant parameters and its interactions: T, S, T × S, T × Y, Y × S, Y × P and S × P × Y

Table 4. Economic of insecticides evaluated against yellow stemborer and leaf folder of rice

Insecticides	Dose (g a.i./ha)	Quantity of insecticides required for two sprays (L/kg/ha)	Cost of insecticides for two sprays (₹)	Total cost of treatments including labour charge (₹/ha)	Yield (q/ha)		Net gain over control (q/ha)		Realization over control (₹/ha)		Total realization over control (₹/ha)	ICBR
					Grain	Straw	Grain	Straw	Grain	Straw		
Cartap hydrochloride 75 SG, 0.075%	375.0	1.00	3500	4797	50.87	76.13	20.84	30.00	27103	6000	33103	1: 6.90
Flubendiamide 4 + buprofezin 20 SC, 0.042%	210.0	1.75	7000	8297	49.28	74.92	19.25	28.79	25035	5759	30794	1: 3.71
Chlorantraniliprole 18.5 SC, 0.006%	30.0	0.30	4800	6097	51.52	77.54	21.50	31.42	27949	6283	34232	1: 5.61
Lambda-cyhalothrin 5 EC, 0.0025%	12.5	0.50	280	1577	41.88	63.91	11.86	17.78	15422	3557	18978	1: 12.04
Carbosulfan 25 EC, 0.05%	250.0	2.00	2000	3297	36.98	62.10	6.96	15.98	9052	3195	12247	1: 3.71
Bifenthrin 10 EC, 0.01%	50.0	1.00	1120	2417	39.25	61.21	9.22	15.09	11995	3018	15013	1: 6.21
Untreated	-	-	-	-	30.02	46.13	-	-	-	-	-	-

Input cost: Labour 324.20 ₹/ day × two labour= 648.40 ₹ /ha/spray; Cartap hydrochloride 75 SG (3500 ₹/1 litre); Flubendiamide 4 + buprofezin 20 SC (4000 ₹/1 litre); Chlorantraniliprole 18.5 SC (480 ₹/30 ml); Lambda-cyhalothrin 5 EC (140 ₹/250 ml); Carbosulfan 25 EC (250 ₹/250 ml); Bifenthrin 10 EC (280 ₹/250 ml)
Output cost: Paddy 1300 ₹/q; Straw 200 ₹/q

carbosulfan 25 EC, 250 g a.i./ha (18.15 and 12.48) were found next best effective treatments in the year 2019 and 2020, respectively.

Pooled over years

The pooled overall year data of infestation of leaf folder clearly indicated that the plot treated with the chlorantraniliprole 18.5 SC, 30 g a.i./ha recorded lowest per cent damaged leaves (7.79/hill) and which was at par with the cartap hydrochloride 75 SG, 375 g a.i./ha (8.09/hill) and flubendiamide 4 + buprofezin 20 SC, 210.0 g a.i./ha (8.27/hill). Among the evaluated insecticides, the highest per cent damaged leaves (13.59/hill) was noticed in plot treated with lambda-cyhalothrin 5 EC, 12.5 g a.i./ha followed by bifenthrin 10 EC, 50 g a.i./ha (13.86/hill) and carbosulfan 25 EC, 250 g a.i./ha (15.21/hill).

The present findings are in agreement with the findings of earlier workers. Suri and Makkar (2016) confirmed cartap hydrochloride 75 SG at 318.7 g a.i./ha to be highly effective against leaf folder. Maji *et al.* (2017) revealed that the combined product flubendiamide 4 + buprofezin 20 SC was highly effective against the leaf folder. The results are also in close association with Karthikeyan (2017) and Shyamrao and Raghuraman (2019) who reported that the chlorantraniliprole 18.5 SC at 150 ml/ha, was found most effective treatment against leaf folder.

Grain and straw yield and economics

The pooled over year grain and straw yield data indicated that, the highest grain and straw yield (51.52 and 77.54 q/ha) was recorded from the plot treated with chlorantraniliprole 18.5 SC, 30 g a.i./ha and it was at par with the cartap hydrochloride 75 SG, 375 g a.i./ha (50.87 and 76.13 q/ha) and flubendiamide 4 + buprofezin 20 SC, 210.0 g a.i./ha (49.28 and 74.92 q/ha). The next treatment lambda-cyhalothrin 5 EC, 12.5 g a.i./ha, bifenthrin 10 EC, 50 g a.i./ha and carbosulfan 25 EC, 250 g a.i./ha recorded 41.88 and 63.91, 39.25 and 61.21 and 36.98 and 62.10 q/ha grain and straw yield, respectively. The data showed that the highest incremental cost benefit ratio (ICBR) (1: 12.04) was obtained from lambda-cyhalothrin 5 EC, 12.5 g a.i./ha followed by cartap hydrochloride 75 SG, 375 g a.i./ha (1: 6.90), bifenthrin 10 EC, 50 g a.i./ha (1: 6.21) and chlorantraniliprole 18.5 SC, 30 g a.i./ha (1: 5.61).

The results are also in close association with Seni and Naik (2017), Karthikeyan (2017), Seni *et al.* (2017), Maji *et al.* (2017), Shyamrao and Raghuraman (2019) and Reddy *et al.* (2019) observed that the chlorantraniliprole 18.5 SC at 0.3 mL/L and ready-mix insecticide of flubendiamide + buprofezin 24 SC treated plots gives highest yield.

Authors' contribution

Conceptualization of research work and designing of experiments (SST, RKG, MBP); Execution of field experiments and data collection (SST, RKG); Analysis of data and interpretation (SST, RKG); Preparation of manuscript (SST, RKG, MBP, SGP, DJK).

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