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Bio-efficacy of new insecticides against paddy earhead bug, *Leptocorisa oratorius* (Fabricius)

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Abstract

The study was conducted to evaluate new insecticide molecules for the management of paddy earhead bug in field condition at College of Agriculture, V. C. Farm, Mandya, University of Agricultural Sciences Bangalore during *kharif* 2020. Nine different insecticides and one untreated control were evaluated. Number of earhead bugs per hill at day before spray (DBS), 1st, 3rd, 5th and 10th day after spray (DAS) were recorded. The data revealed that among different treatments fipronil 5 SC @ 2.00 mL L^{-1} was most effective with significantly lower population (0.10 bugs/hill) compared to rest of the treatments at 10 DAS. The grain and fodder yield were also significantly higher in fipronil 5 SC @ 2.00 mL L^{-1} treated plot followed by thiamethoxam 25 WG @ 0.30 g L^{-1}. The results of the cost economics for the management of earhead bug revealed that fipronil 5 SC @ 2.00 mL L^{-1} recorded highest net returns with maximum benefit cost ratio (3.02: 1).

Keywords: Earhead bug, management, cost economics, fipronil, thiamethoxam

Introduction

Rice (*Oryza sativa* Linn.) is the principal food for more than half of the world's population and contributes about 40 per cent of the total food grain production. Rice plays a vital role in the human diet, economy, employment, culture and history. The rice crop is subject to attack by more than 100 species of insects and twenty of them can cause economic damage (Pathak and Khan,1994).

Approximately 52 per cent of the overall global rice production is affected annually due to biotic agents, out of which 21 per cent is due to insect pest attacks (Brookes and Barfoot, 2003; Sarao *et al.*, 2015). In India also insect pest damage at various stages of crop growth is a major constraint in rice production. Rice earhead bug or Rice gundhi bug, *Leptocorisa oratorius* (Hemiptera: Alydidae) is an important pest of rice (Rao and Prakash, 1995). Both nymphs and adults cause damage by feeding on the sap of milky grain and make them partial or completely chaffy under severe infestation. At the site of feeding, small yellowish-brown spot is developed initially and enlarge later to form yellowish brown elliptical spot with greyish centre. Both nymphs and adults emit pungent odour when disturbed. Rice gundhi bug is considered as sporadic pest of rice and one of the serious pests of rice in India and sometimes reduce the yield by as much as 30 per cent. The adults are slender and brown-green, measure 19-16 mm long. The early instars are pale in colour. The nymphs have long antennae. The older instars measure 1.8-6.2 mm long, yellowish green. The eggs are oval, shiny, and reddish brown laid in batches of 10-20 in one to three rows along the midrib on the upper surface of the leaf (Tiwari *et al.*,2014).

The incidence and damage caused by earhead bug across rice ecosystem is increasing day by day in major rice growing areas of southern Karnataka particularly Cauvery command area. In view of this, the present investigation was conducted to evaluate different new insecticides against paddy earhead bug.

Materials and methods

The field experiment was conducted during late *kharif* 2020 at "A" block, College of Agriculture, V. C. Farm Mandya to evaluate new and conventional insecticides against paddy earhead bug.

Experiment was laid-out in Randomized Completely Block Design (RCBD) with 10 treatments, including an untreated control (**Table 4**) and replicated thrice. The popular and susceptible variety IR-64 was sown with a spacing of 20 X 15 cm, between rows and plants, respectively. For each replication, a plot size of 3 X 3 m was maintained. All packages of practices were followed in the plot except plant protection measures (Anon., 2017).

The observations were recorded by counting the number of bugs visually on 10 hills per plot at random in each replication. Observations were made on a day before spray, and at 1st, 3rd, 5th and 10th days after spray. Per cent reduction over untreated control was worked out using modified Abbot's formula. Harvest was made at physiological maturity; grain yield and fodder yield were recorded treatment wise. The data on grain yield per plot was converted into quintal per hectare. In each treatment the additional gain yield over untreated control was calculated as below

$$\%\ \text{Additional gain yield} = \frac{\text{Yield in treatment- yield in control}}{\text{Yield in control}} \times 100$$

Data were subjected to ANOVA (Gomez and Gomez, 1984; Hosmand, 1988) and means were separated by Tukey's HSD (Tukey, 1965). Further, cost economics of each treatment was worked out as per market price, labour wages and additional costs during the course of study and benefit cost ratio was calculated.

Results and discussion

A day before spray, the population of earhead bug in each treatment varied between 1.10 to 2.53 bugs/hill and there was no significant difference among the treatments. At 1DAS, population of earhead bug among treatments ranges from 0.23 and 1.80 per hill. significantly lower population (0.23 bugs/hill) was recorded in fipronil 5 SC @ 2.0 mL L^{-1} followed by thiamethoxam 25 WG @ 0.30 g L^{-1} (0.30 bugs/hill). These treatments were followed by flonicamid 50 WG @ 0.25 g L^{-1}, imidacloprid 17.8 SL @ 0.30 mL L^{-1}, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1}, acetamiprid 20 SP @ 0.30 g L^{-1} and deltamethrin 2.8 EC @ 1.00 mL L^{-1} which recorded 0.37, 0.40, 0.40, 0.43 and 0.47 bugs/hill, respectively and were on par with each other. The next best treatments were dinotefuran 20 SG @ 0.30 g L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} which recorded 0.63 and 1.07 bugs/hill, respectively and were significantly differed. However, a significantly higher earhead bug population (1.80 bugs/hill) was recorded in untreated control (**Figure 1**).

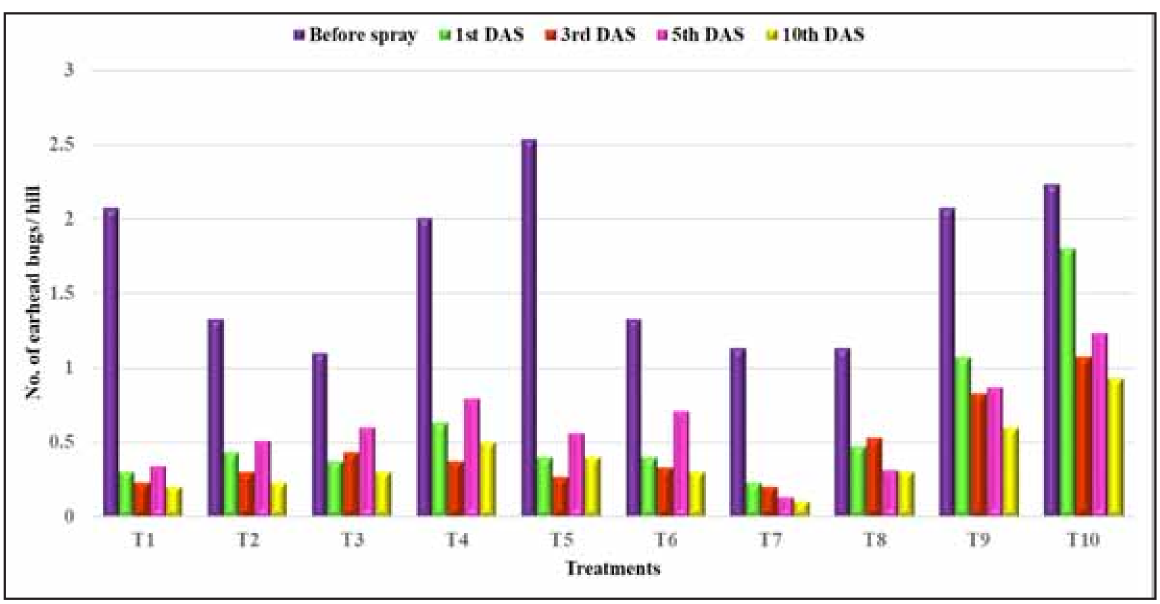

Figure 1: Earhead bug population in different treatments

Likewise, at 3 DAS, similar trend was observed and lower population (0.20 bugs/hill) observed in fipronil 5 EC @ 2.0 mL L^{-1} followed by thiamethoxam 25 WG @ 0.30 g L^{-1} (0.23 bugs/hill). The next best treatments were imidacloprid 17.8 SL @ 0.30 mL L^{-1}, acetamiprid 20 SP @ 0.30 g L^{-1}, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1}, dinotefuran 20 SG @ 0.30 g L^{-1} and flonicamid 50 WG @ 0.25 g L^{-1} which recorded 0.27, 0.30, 0.33, 0.37 and 0.43 bugs/hill, respectively and were on par with each other. Likewise, the earhead bug population in deltamethrin 2.8 EC @ 1.00 mL L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} was 0.53 and 0.83 bugs/hill, respectively and were on par with each other. However, an increase in earhead bug population was observed in untreated control (1.07 bugs/hill).

At 5 DAS, significantly higher population of earhead bug was observed in untreated control (1.23 bugs/hill) and was followed by dimethoate 30 EC @ 2.00 mL L^{-1} (0.87 bugs/hill) and were on par with each other. The next best treatments were dinotefuran 20 SG @ 0.30 g L^{-1}, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1}, flonicamid 50 WG @ 0.25 g L^{-1} and imidacloprid 17.8 SL @ 0.30 mL L^{-1} which recorded 0.79, 0.71, 0.60 and 0.56 bugs/ hill, respectively and were found on par with each other.

Significantly lower population (0.13 bugs/hill) was observed in fipronil 5 SC @ 2 mL L^{-1} and superior over rest of the treatments followed by thiamethoxam 25 WG @ 0.30 g L^{-1} and deltamethrin 2.8 EC @ 1.00 mL L^{-1} (0.34 and 0.31 bugs/hill respectively) and were on par with each other. The lowest earhead bug population.

At 10 days after spraying, significantly lower population was observed in fipronil 5 SC @ 2.00 mL L^{-1} (0.10 bugs/hill) and but was on par with thiamethoxam 25 WG @ 0.30 g L^{-1} (0.20 bugs/hill), acetamiprid 20 SP @ 0.30 g L^{-1}, flonicamid 50 WG @ 0.25 g L^{-1}, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1} and deltamethrin 2.8 EC @ 1.00 mL L^{-1} (0.23, 0.30, 0.30 and 0.30 bugs/hill, respectively). Likewise, the earhead bug population in imidacloprid 17.8 SL @ 0.30 mL L^{-1}, dinotefuran 20 SG @ 0.30 g L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} were 0.40, 0.50 and 0.60 bugs/hill, respectively and were on par with each other. However, significantly higher earhead bug population (0.93 bugs/hill) was recorded in untreated control **(Table 1).**

Among the insecticides tested, the highest per cent reduction of earhead bug population (78.78 %) over untreated control was recorded in fipronil 5 SC @ 2.0 mL L^{-1} and this was followed by thiamethoxam 25 WG @ 0.30 g L^{-1} (76.83 %) and imidacloprid 17.8 SL @ 0.30 mL L^{-1} (62.09 %). Likewise, the per cent reduction of earhead bug population over untreated control in acetamiprid 20 SP @ 0.30 g L^{-1}, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1}, dinotefuran 20 SG @ 0.30 g L^{-1}, deltamethrin 2.8 EC @ 1.00 mL L^{-1}, flonicamid 50 WG @ 0.25 g L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} was 58.53, 45.91, 40.05, 36.53, 34.60 and 30.39 per cent, respectively (**Table 16; Figure 7**).

The insecticides in the decreasing order of their efficacy were fipronil 5 SC @ 2.0 mL L^{-1} > thiamethoxam 25 WG @ 0.30 g L^{-1} > imidacloprid 17.8 SL @ 0.30 mL L^{-1} > acetamiprid 20 SP @ 0.30 g L^{-1} > lambda cyhalothrin 5 EC @ 1.00 mL L^{-1} > dinotefuran 20 SG @ 0.30 g L^{-1} > deltamethrin 2.8 EC @ 1.00 mL L^{-1} > flonicamid 50 WG @ 0.25 g L^{-1} > dimethoate 30 EC @ 2.00 mL L^{-1}.

Sharma *et al.* (2019) who found that the plots treated with fipronil 5% + buprofezin 20% SC recorded the lowest number of rice earhead bug population (2.10 and 3.51 nos./5 sweep nets) after first and second insecticidal sprays, respectively, followed by indoxacarb 10% + thiamethoxam 10% WG (2.47 and 4.25 nos./5 sweep nets, respectively). Seni and Naik (2017) reported that thiamethoxam 25 WG @ 37.50 g a.i /ha treated plot recorded significantly higher % reduction of hoppers (>60% over untreated control) and fipronil 5 SC @ 75 g a.i/ha treated plot had lower number of silver shoot (2.6%) incidence.

The results are in conformity with the results of Rath *et al.* (2015), who reported imidacloprid 17.8% @ 300 g/ha treatment recorded lowest percentage of DH (3.3%), WEH (3.33%), gundhi bug damage (7.16%). Thiamethoxam 25 WG @ 0.3 g/l, registered its superiority over rest of the treatments by recording lowest ear head bug population and higher grain yield followed by malathion 5D @ 20 kg/ha. In other insecticidal treatments the level of ear head bug population was comparatively high (Girish and Balikai, 2015). Ashokappa *et al*. (2015) also reported that insecticides, imidacloprid 17.8 SL @ 0.25 ml/l, thiamethoxam 25 WG @ 0.3 g/l and malathion D @ 20 kg/ha recorded earhead bug lowest population (0.05,0.14 and 0.18 bugs/hill). Likewise, Krishna and Ashwani (2017) who found that the treatment Imidacloprid was recorded lowest population of gundhi bug with (0.91 bug/hill) and found to be superior among all other treatments. This was followed by thiamethoxam (1.22 bug/hill). Similar results were reported by Shafia and Singh (2016), where they tested various test concentrations of chlorpyrifos 35%+fipronil 3.5% EC against rice gundhi bug, *Leptocorisa varicornis* (Fabr) and reported that a mean reduction in population of rice gundhi bug was found to be 4.78, 5.11, 5.17 and 9.73 for chlorpyrifos 35%+Fipronil 3.5% EC @ 875+87.5, 525+52.5, 437.5+43.75 and 350+35 g a.i./ha treatments, respectively when compared to untreatedcontrol (15.98).

In the present study, grain yield was significantly varied from 39.56 to 59.33 q ha^{-1}. Among the different treatments, significantly highest grain yield was recorded in fipronil 5 SC @ 2 mL L^{-1} of 59.33 q ha^{-1} and this was followed by thiamethoxam 25 WG @ 0.30 g L^{-1}, imidacloprid 17.8 SL @ 0.30 mL L^{-1} and acetamiprid 20 SP @ 0.30 g L^{-1} which recorded 57.33, 54.67 and 53.44 q ha^{-1}, respectively and were on par with each other. The treatment, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1} recorded 51.44 q ha^{-1} was on par with dinotefuran 20 SG @ 0.30 g L^{-1} recorded 44.89 q ha^{-1}. Whereas, flonicamid 50 WG @ 0.25 g L^{-1} recorded 43.67 q ha^{-1} and was on par with deltamethrin 2.8 EC @ 1.00 mL L^{-1} (41.33 q ha^{-1}), which was the next best treatment in recording grain yield. The treatment, dimethoate 30 EC @ 2.00 mL L^{-1} recorded 41.11 q ha^{-1}. However, significantly lowest yield of 39.56 q ha^{-1} was recorded in untreated control (**Table 2**). Plant biomass yield did not vary significantly among different treatments in the present study. However, highest biomass yield of 64.55 q ha^{-1} was recorded in fipronil 5 SC @ 2 mL L^{-1} followed by acetamiprid 20 SP @ 0.30 g L^{-1} and deltamethrin 2.8 EC @ 1.00 mL L^{-1} which recorded 62.00 and 60.33 q ha^{-1}. The lowest biomass yield (54.11 q ha^{-1}) was recorded in untreated control.

The results of the present findings are in close agreement with that of Ashokappa *et al.* (2015), who reported imidacloprid 17.8 SL @ 0.25 ml/l treated plot recorded highest grain yield of 7049.26 kg/ha followed by thiamethoxam 25 WG @ 0.3 g/l and malathion D @ 20 kg/ha which recorded 6461.11 and 6253.33 kg/ha, respectively. Similarly, Girish and Balikai (2015), observed highest grain yield in thiamethoxam 25 WG @ 0.3 g/l treated plot followed by malathion 5D @ 20 kg/ha. Likewise, Rath *et al.* (2015), who found that imidacloprid 17.8% @ 300 g/ha treatment recorded highest grain yield of 5.28 t/ha in variety Jaya followed by the treatment sulfoxaflor 24% @ 375 g/ha, 4.96 t/ha, thiamethoxam 25% @ 100 g/ha, 4.9 t/ha and triazophos 40% @ 625 g/ha, 4.78 t/ha.

The results of the cost economics for the management of earhead bug revealed that fipronil 5 SC @ 2 mL L^{-1} registered higher gross returns of Rs.122456 ha^{-1} resulting in maximum net profit of Rs.91998 ha^{-1}. This was followed by thiamethoxam 25 WG @ 0.30 g L^{-1}, imidacloprid 17.8 SL @ 0.30 mL L^{-1} and acetamiprid 20 SP @ 0.30 g L^{-1} which recorded gross returns of Rs.117712, Rs.112905 and Rs.110986 ha^{-1} with net profit of Rs.87799, Rs.83019 and Rs.81808 ha^{-1}, respectively. Likewise, lambda cyhalothrin 5 EC @ 1.00 mL L^{-1}, dinotefuran 20 SG @ 0.30 g L^{-1}, flonicamid 50 WG @ 0.25 g L^{-1}, deltamethrin 2.8 EC @ 1.00 mL L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} were recorded gross returns of Rs.106007, Rs.94798, Rs.91349, Rs.87680 and Rs.87647 ha^{-1} respectively with net return of Rs.76734, Rs.63799, Rs.60022, Rs.58144 and Rs.57490 ha^{-1}, respectively. Whereas, untreated control recorded minimum net profit (Rs. 54072 ha^{-1}) compared to rest of the treatments.

Similarly, the highest benefit cost ratio (3.02:1) was recorded in fipronil 5 SC @ 2.00 mL L^{-1} followed by, thiamethoxam 25 WG @ 0.30 g L^{-1}, acetamiprid 20 SP @ 0.30 g L^{-1}, imidacloprid 17.8 SL @ 0.30 mL L^{-1} and lambda cyhalothrin 5 EC @ 1.00 mL L^{-1} which recorded benefit cost ratio of 2.94:1, 2.80:1, 2.77:1 and 2.62:1, respectively. The next best benefit cost ratio observed in dinotefuran 20 SG @ 0.30 g L^{-1} and deltamethrin 2.8 EC @ 1.00 mL L^{-1} with benefit cost ratio of 2.05 and 1.96 respectively. However, very low benefit cost ratio among the treatment was recorded in flonicamid 50 WG @ 0.25 g L^{-1} and dimethoate 30 EC @ 2.00 mL L^{-1} with 1.92 and 1.90 respectively, although, in control it was the lowest (1.89:1) **(Table 2).**

The present findings are in accordance with reports of Gupta *et al*. (2019), who found highest benefit cost ratio in imidacloprid (1:2.66), followed by triazophos (1:2.53), monocrotophos (1:2.49), acephate (1:2.41), thiamethoxam (1:2.40), carbaryl (1:2.35), malathion (1:2.19) as compared to control (1:1.74). Similarly, Girish and Balikai (2015), reported thiamethoxam 25 WG @ 0.3 g/l treated plot recorded highest net profit of Rs. 65823.75 followed by malathion 5 D @ 20 kg/ha (Rs. 62070.63) against earhead bug in paddy.

Table 1. Bio-efficacy of insecticides against paddy earhead bug, *Kharif* 2020

Sl. No.	Treatments	Dose (mL or g L^{-1})	Number of earhead bugs/hills					Per cent reduction over control
			Before spray	1st DAS	3rd DAS	5th DAS	10th DAS	
1	Thiamethoxam 25 WG	0.30	2.07 (1.60)	0.30 (0.89)^{a}	0.23 (0.86)^{a}	0.34 (0.92)^{ab}	0.20 (0.84)^{ab}	76.83
2	Acetamiprid 20 SP	0.30	1.33 (1.35)	0.43 (0.97)^{ab}	0.30 (0.89)^{ab}	0.51 (1.00)^{bc}	0.23 (0.86)^{abc}	58.53
3	Flonicamid 50 WG	0.25	1.10 (1.26)	0.37 (0.93)^{ab}	0.43 (0.97)^{ab}	0.60 (1.05)^{bcd}	0.30 (0.89)^{abc}	34.60
4	Dinotefuran 20 SG	0.30	2.00 (1.58)	0.63 (1.06)^{b}	0.37 (0.93)^{ab}	0.79 (1.13)^{cd}	0.50 (1.00)^{cd}	40.05
5	Imidacloprid 17.8 SL	0.30	2.53 (1.54)	0.40 (0.95)^{ab}	0.27 (0.88)^{ab}	0.56 (1.03)^{bcd}	0.40 (0.95)^{bcd}	62.09
6	Lambda cyhalothrin 5 EC	1.00	1.33 (1.35)	0.40 (0.95)^{ab}	0.33 (0.91)^{ab}	0.71 (1.10)^{cd}	0.30 (0.89)^{abc}	45.91
7	Fipronil 5 SC	2.00	1.13 (1.28)	0.23 (0.86)^{a}	0.20 (0.84)^{a}	0.13 (0.80)^{a}	0.10 (0.77)^{a}	78.78
8	Deltamethrin 2.8 EC	1.00	1.13 (1.28)	0.47 (0.98)^{ab}	0.53 (1.02)^{bc}	0.31 (0.90)^{ab}	0.30 (0.89)^{abc}	36.53
9	Dimethoate 30 EC	2.00	2.07 (1.60)	1.07 (1.25)^{c}	0.83 (1.15)^{cd}	0.87 (1.17)^{de}	0.60 (1.05)^{d}	30.39
10	Untreated control	-	2.23 (1.65)	1.80 (1.52)^{d}	1.07 (1.25)^{d}	1.23 (1.31)^{e}	0.93 (1.20)^{e}	-
SE m±			NS	0.03	0.03	0.03	0.03	-
CD @ p=0.05				0.10	0.09	0.10	0.09	

Values in the column followed by common letters are non-significant at p=0.05 as per Tukey's HSD (Tukey, 1965); DAS: Days after spraying; NS: Non significant; Per cent reduction over untreated control as per Flemming and Ratnakaran, 1985; Figures in the parenthesis indicate $\sqrt{x+0.5}$ transformed values.

Table 2. Cost economics of different insecticides for the management of paddy earhead bug, *Kharif* 2020

Sl. No.	Treatments	Dose (mL or g L^{-1})	Yield (q/ha)		Gross return (Rs. /ha)	Cost involved (Rs)		Total cost (Rs./ ha)	Net profit (Rs./ ha)	B:C ratio
			Grain	Bio-mass		Cost of insecticides	Other expenditure			
1	Thiamethoxam 25 WG	0.30	57.33	59.00	117712	1413.00	28500.00	29913	87799	2.94 : 1
2	Acetamiprid 20 SP	0.30	53.44	62.00	110986	678.00	28500.00	29178	81808	2.80 : 1
3	Flonicamid 50 WG	0.25	43.67	54.33	91349	2827.00	28500.00	31327	60022	1.92 : 1
4	Dinotefuran 20 SG	0.30	44.89	60.77	94798	2499.00	28500.00	30999	63799	2.05 : 1
5	Imidacloprid 17.8 SL	0.30	54.67	59.88	112905	1386.00	28500.00	29886	83019	2.77 : 1
6	Lambda cyhalothrin 5 EC	1.00	51.44	55.11	106007	773.00	28500.00	29273	76734	2.62 : 1
7	Fipronil 5 SC	2.00	59.33	64.55	122456	1958.00	28500.00	30458	91998	3.02 : 1
8	Deltamethrin 2.8 EC	1.00	41.33	58.22	87680	1036.00	28500.00	29536	58144	1.96 : 1
9	Dimethoate 30 EC	2.00	41.11	60.33	87647	1657.00	28500.00	30157	57490	1.90 : 1
10	Untreated control	-	39.56	54.11	82572	-	28500.00	28500	54072	1.89 : 1

Price of rice grain= Rs. 1868 per quintal; Price of fodder= Rs. 180 per quintal (As per APMC, Mandya, August 2021)

Conclusion

From the results of the present study, we can conclude that fipronil 5 SC @ 2.00 mL L^{-1}, thiamethoxam 25 WG @ 0.30 g L^{-1} and imidacloprid 17.8 SL @ 0.30 mL L^{-1} were found to be effective for the management of paddy earhead bug with highest monetary returns. However, fipronil 5 SC @ 2mL L^{-1} recorded higher grain yield, net returns and B:C ratio (3.02:1) compared to other treatments.

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