Advances
2025, Vol. 6, No. 2, pp. 57-63
https://doi.org/10.11648/j.advances.20250602.14

Research Article

Efficacy of Different Insecticides for the Control of Rice Stalk-eyed Shoot Fly (*Diopsis longicornis*) Under Field Condition at Pawe, Northwestern Ethiopia

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Abstract

Several insects feed on rice, but stalk-eyed shoot fly is considered the most important rice pests. Among the insect management options, the use of insecticides is suitable for immediate action and remained an exclusive management method in the countries where agricultural technologies are not well advanced. The present study aimed to evaluate the effectiveness of seven insecticides *viz*., Hanclopa 48% EC, Dimeto 40% EC, Datrate 5% EC, Diazinon 60% EC, Fipronil 5% SC, Alpha-Cyproid 10% EC and Star Profenofos 72% EC at Pawe Agricultural Research Center (PARC) of the Ethiopian Institute of Agricultural Research (EIAR) during 2018 and 2019 cropping seasons at Pawe village 17. The treatments were arranged in a randomized complete block design (RCBD) with three replications and X-jigna rice variety was used. The results revealed that applications of insecticides were found effective over the unsprayed control. The lowest number of dead heart per plot (47.17 per plot) was recorded on the plot treated with Alpha-Cyproid 10% EC insecticide which gave the highest grain yield of (3503.50 kg ha^{-1}), followed by Fipronil 5% SC (3166 kg ha^{-1}). Therefore, the present result suggests that twice application of Alpha-Cyproid 10% EC insecticide at a rate of 0.4 Lha^{-1} is effective for the management of rice stalk-eyed shoot fly in Pawe and other areas with a similar condition. Further study should consider evaluation of larger number of insecticides against the insect both in green house and under field condition.

Keywords

Alpha-Cyproid, Dead Heart Symptom, Infestation, Larval Stage, Management

1. Introduction

Rice (*Oryza sativa* L.) is the dominant staple food in the developing world. More than 90% of the world's rice is produced and consumed in Asia. Global production for 2014 was estimated at 740.2 million tons (Mt) with China, India, Indonesia, Vietnam, Thailand and Bangladesh being the major producers [1]. In East Africa, rice is the second most important staple food, after maize. By 2014, annual consumption had reached 1.8 million metric tons. Production, however, stood at 1.25 million metric tons [1].

Rice production is constrained by several biotic and abiotic factors. Biotic factors like weeds, insect pests (stem borers such as stalk-eyed flies, African rice gall midge and rice bugs), diseases (blast, brown spot, and viral diseases), rats and birds are among the major constraints [2].

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Received: 4 May 2025; **Accepted:** 23 May 2025; **Published:** 23 June 2025

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Several insects feed on rice, but stem borers are considered the most important rice pests, in particular *Scirpophaga incertulas* and *S. innotata* (Walker) (Lepidoptera: Pyralidae). Stem borer *S. incertulas* usually comprised more than 90% of the borer population in rice. The onset of flooding and stem elongation provided a more favorable environment for *S. incertulas*. The rice borers' activity increased steadily during the first 3 to 4 months of flooding, to average 23% damaged stems by the flowering stage. Borer's activity continued at about the same level as the water receded; to reach maximum annual levels of 38 to 44% damaged stems at the late-ripening stage. At harvest, 60% of the fields were at outbreak level (> 40% damaged stems) [3]. It is the serious pest species of rice throughout the Orient, and abundant both on lowland rice and upland rice attacking young plant even in the nursery stage [4]. These borers vary in severity of damage and population intensity. The rice stem borer, infesting the plant from seedling to maturity, is one of the main problems and yields limiting factors in the rice fields [5].

Estimates of yield losses due to insects in Africa range from 10 to 15% [6]. Stalk-eyed flies (*Diopsis longicornis and Diopsis apicalis*) are among the stem borers which are widely-distributed and devastating pests of rice [7]. Stalk-eyed shoot fly larvae usually affects the central meristem of the plant, which is bored, resulting in a condition known as dead heart. The consequences of the assault by rice stem borers in many crops mainly in the rice are labeled signified by the dead hearts and white heads in first stage and later the panicle get infested [8]. Stalk-eyed shoot fly damage significantly reduces the tiller density, number of panicles, grain weight and numbers of mature panicles [9].

Among the pest management options, insecticides are a practical way to control insects; and its use has a positive effect on rice production [10]. The application of pesticides or the development of resistant types are the most effective ways to manage diseases and pests, but excessive pesticide use will definitely contaminate rice products and the environment [11].

Farmers depend upon a great deal of insecticide applications, even though a lot of insecticide applications are not effectual [5]. The challenge today is to produce effective insecticides since the pest is not being easily contaminated by the most of the insecticides [12]. In Ethiopia, management options for stalk-eyed shoot fly are not recommended and the constraint is enhanced gradually. Therefore, this study was initiated to evaluate registered insecticides and identify the most effective ones for the control of rice stalk-eyed shoot fly.

2. Materials and Methods

2.1. Site Description

The experiment was conducted at Pawe Agricultural Research Center (PARC) of Ethiopian Institute of Agricultural Research (EIAR) from June to October during 2018 and 2019. The center is located 11°19`N and 36°24`E at a height of 1120 meters above sea level (m.a.s.l.). The center receives an average rainfall of 1586 mm with mean monthly minimum and maximum temperature of 16.5℃ and 32.7℃, respectively. The area has been experienced high rice disease and insect pest pressure in the country due to the prevailing high relative humidity which more than 75%, and other suitable weather conditions and cropping systems for the development of pests.

2.2. Treatments, Experimental Design, and Procedures

Eight treatments consisting of seven insecticides and one negative check (untreated plot) were evaluated under natural infection of rice stalk-eyed shoot fly at field conditions of upland rice ecosystem at Pawe Agricultural Research Center, village 17 for the control of stalk-eyed shoot fly. For all treatments, X-jigna rice variety was planted in randomized complete block design (RCBD) with three replications. All agronomic practices were applied as per the recommendations. The plot size was 2.4 m * 3 m, and blocks, plots and rows were spaced by 1 m, 1 m and 0.2m, respectively.

Table 1. *Weather conditions at PARC during 2018 and 2019 cropping seasons.*

Months	2018				2019			
	Min T (℃)	Max T (℃)	RF (mm)	RH (%)	Min T (℃)	Max T (℃)	RF (mm)	RH (%)
January	12.61	34.43	0.00	65.90	13.84	36.18	0.00	78.42
February	16.66	38.03	0.00	63.93	17.08	36.75	0.00	58.53
March	16.97	38.17	0.00	59.68	19.32	38.00	0.00	59.68
April	18.55	37.99	0.00	65.00	21.41	38.50	0.00	63.13
May	19.85	35.51	170.70	64.66	21.46	35.59	97.30	74.40
June	18.97	29.93	315.70	85.97	18.78	30.32	309.70	84.33

Months	2018				2019			
	Min T (℃)	Max T (℃)	RF (mm)	RH (%)	Min T (℃)	Max T (℃)	RF (mm)	RH (%)
July	18.01	28.82	338.20	85.87	18.51	27.85	422.20	86.90
August	17.66	28.61	339.90	88.77	18.39	27.67	261.50	83.70
September	17.74	30.11	131.00	86.90	18.25	28.77	353.10	88.94
October	17.81	30.50	150.00	89.00	17.75	30.06	242.80	88.72
November	15.81	32.31	70.00	81.74	16.78	30.86	36.80	79.45
December	14.96	33.51	0.00	79.03	14.54	32.70	3.00	78.90
Mean	17.13	33.16	126.29	76.37	18.01	32.77	143.87	77.09

2.3. Insecticide Application

Chemical insecticides used in this study comprised of seven (7) registered insecticides in Ethiopia for the control of different insect pests on various crops. The test insecticides were applied using a lever-operated knapsack sprayer at the first appearance of dead heart symptoms (i.e., August 05 in 2018 and August 20 in 2019) and then repeated once after 14 days following the manufacturer's recommendation rate for each insecticide (Table 2).

Table 2. *Insecticide's trade name, active ingredients and application rate ha^{-1}.*

SN	Trade name	Common name (Active ingredients)	Application rate ha^{-1}
1	Dimithoate 40% EC	Dimeto 40% EC	950ml
2	Lambda cyhalothrin 5% EC+95% others	Datrate 5% EC	320ml
3	Vetazinon 60% EC	Diazinon 60%EC	1L
4	Fipronil 5% SC+ other inert materials	Lipron 50 SC	3L
5	Lambda cyhalothrin 5% +W/V+95 W/V inert materials	Hanclopa 48% EC	400ml
6	Alpha cypermethrin 100g/lit+ 90 g/lit inert ingredient	Alpha-Cyproid 10% EC	0.4L
7	Profenofos 72%EC	Star Profenofos 72%EC	500ml

2.4. Number of Dead Heart and Agronomic Parameters

Besides dead heart data, agronomic data related to yield such as plant height (cm), panicle length (cm), number of filled grain per panicle, number of unfilled grain per panicle, thousand seed weight (g), and grain yield (kg ha^{-1}) were collected based on the standard evaluation system for rice [13] and subsequently subjected to statistical analysis.

2.5. Data Analysis

The data were arranged on Microsoft Excel and analyzed in R software [14]. One-way analysis of variance (ANOVA) was used to determine the level of significant difference among insecticides at 5% level of probability.

3. Results

3.1. Effect of Insecticides Application on Rice Stalk-Eyed Shoot Fly

In 2018, the application of all insecticides has significantly reduced the number of dead hearts compared to the control except Fipronil with significant variation among the insecticides at 5% probability level. The number of dead hearts was ranged from 33.67-54.77 per plot with the mean of 44.80 (Table 3, Figure 1).

Table 3. *Effect of different insecticides on rice stalk-eyed shoot fly (dead heart) and rice crop yield and yield component parameters, during 2018.*

Insecticide	PH	PL	NFGPP	NUnFGPP	TSW	GY	NDH
Hanclopa 48% EC	99.00	18.80^{ab}	107.13^{ab}	9.13^{a}	26.70	3312.32^{ab}	33.67^{b}
Diazinon 60% EC	94.73	17.67^{b}	91.80^{c}	5.60^{c}	27.00	2932.93^{b}	38.67^{ab}
Control	97.27	19.07^{ab}	104.93^{abc}	8.07^{abc}	26.33	2887.84^{b}	54.77^{a}
Alpha-Cyproid 10% EC	98.73	18.33^{ab}	99.07^{bc}	8.27^{ab}	26.17	3771.24^{a}	49.00^{ab}
Star Profenofos 72% EC	97.67	19.20^{ab}	107.20^{ab}	6.47^{bc}	26.00	3263.51^{ab}	38.67^{ab}
Dimeto 40% EC	98.07	18.87^{ab}	108.00^{ab}	6.47^{bc}	26.47	3118.46^{b}	45.33^{ab}
Datrate 5% EC	95.07	17.73^{ab}	94.67^{bc}	6.8^{abc}	26.33	3403.24^{ab}	47.00^{ab}
Fipronil 5% SC	99.60	19.67^{a}	118.40^{a}	9.13^{a}	26.67	3270.19^{ab}	51.33^{a}
Mean	97.55	18.67	103.90	7.49	26.46	3244.96	44.80
CV (%)	3.24	6.04	7.96	19.78	3.21	10.60	21.80
LSD (p<0.05)	NS	*	*	*	NS	*	*

Means followed by the same letter in the same column are not statistically different at 5%.
PH= Plant height (cm), PL= Panicle length (cm), NFGPP= Number of filled grain per panicle, NUnFGPP= Number of unfilled grain per panicle, TSW= Thousand seed weight (gm), GY = Grain yield (Kg ha^{-1}) and NDH= Number of dead heart

During 2019 cropping season, means of insecticides were not significantly varied for the number of dead heart with the range of 45.33-76.00 per plot (63.42, mean). The lowest number of dead heart per plot was recorded on the plot treated with Alpha-Cyproid 10% EC (45.33), while the highest number of dead heart was recorded on the untreated plot (76), followed by the plot treated with Star Profenofos 72% EC (72) and Hanclopa 48% EC (71.33) (Table 4, Figure 1).

Table 4. *Effect of different insecticides on rice stalk-eyed shoot fly (dead heart) and rice crop yield and yield component parameters, during 2019.*

Insecticide	PH	PL	NFGPP	NUnFGPP	TSW	GY	NDH
Hanclopa 48% EC	97.87^{ab}	18.13^{abc}	101.80^{abc}	4.07^{b}	26.17	2518.55	71.33
Diazinon 60% EC	93.80^{b}	16.60^{c}	83.27^{c}	6.47^{ab}	25.83	2319.92	59.67
Control	97.33^{ab}	18.20^{abc}	99.87^{abc}	5.93^{ab}	26.67	2342.67	76.00
Alpha-Cyproid 10% EC	104.30^{a}	18.70^{ab}	105.53^{ab}	4.80^{b}	25.83	3235.75	45.33
Star Profenofos 72% EC	96.93^{ab}	17.53^{bc}	88.13^{bc}	5.67^{b}	25.17	2398.08	72.33
Dimeto 40% EC	102.20^{ab}	19.47^{a}	109.80^{a}	9.00^{a}	26.67	2910.54	65.67
Datrate 5% EC	101.27^{ab}	17.87^{abc}	96.87^{abc}	6.67^{ab}	26.17	2555.00	57.67
Fipronil 5% SC	99.33^{ab}	17.80^{abc}	85.47^{c}	5.80^{ab}	25.33	3062.50	59.33
Mean	99.13	18.04	96.34	6.05	25.98	2667.88	63.42
CV (%)	5.72	5.60	11.03	30.52	4.86	20.99	31.74
LSD (p<0.05)	*	*	*	*	NS	NS	NS

Means followed by the same letter in the same column are not statistically different at 5%.
PH= Plant height (cm), PL= Panicle length (cm), NFGPP= Number of filled grain per panicle, NUnFGPP= Number of unfilled grain per panicle, TSW= Thousand seed weight (gm), GY = Grain yield (Kg ha^{-1}), and NDH= Number of dead heart.

3.2. Effect of Insecticides Application on Rice Grain Yield

The analysis of variance revealed that the means of insecticides were significantly varied ($P < 0.05$) for plant height, panicle length, number of filled grain per panicle and grain yield while there was no variation among treatments for number of unfilled grain per panicle and thousand seed weight.

The grain yield was statistically different among test insecticides during 2018 cropping season and application of Alpha-Cyproid 10% EC resulted in the highest grain yield (3771.24 kg ha^{-1}), followed by Datrate 5% EC (3403.24 kg ha^{-1}) and Hanclopa 48% EC (3312.32 kg ha^{-1}) (Table 2).

Similarly, during 2019 cropping season Alpha-Cyproid 10% EC insecticide application gave the highest grain yield (3235.75 kg ha^{-1}), followed by Fipronil 5% SC (3062.50 kg ha^{-1}) (Table 3). The lowest grain yield was harvested from the untreated plot during 2018 (2887.84 kg ha^{-1}) and from the plot treated with Diazinon 60% EC (2319.92 kg ha^{-1}) and untreated plot (2342.67 kg ha^{-1}) during 2019 cropping season. As reflected in table 4, the grain yield was found statistically different among the insecticides and the highest overall mean of grain yield was obtained in the plot treated with Alpha-Cyproid 10% EC (3503.50 kg ha^{-1}), followed by Fipronil 5% EC (3166.35 kg ha^{-1}) and Dimeto 40% EC (3014.50 kg ha^{-1}), while the lowest (2615.26 kg ha^{-1}) was obtained in control (untreated plot), followed by the plot treated with Diazinon 60% EC (2626.43 kg ha^{-1}) (Figure 2).

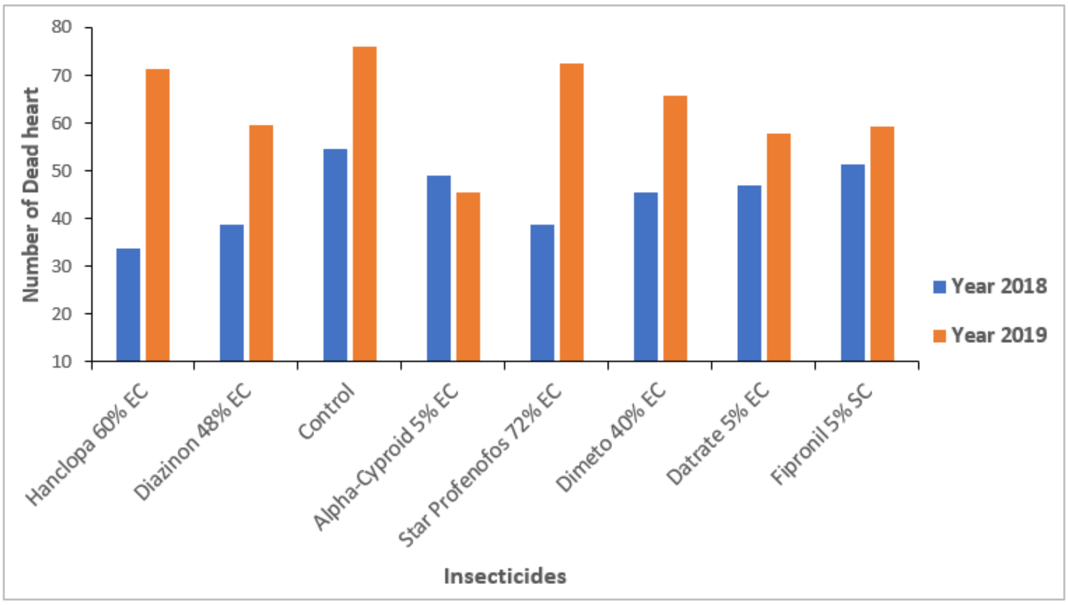

Figure 1. *Effect of insecticides on number of dead heart of rice in 2018 and 2019.*

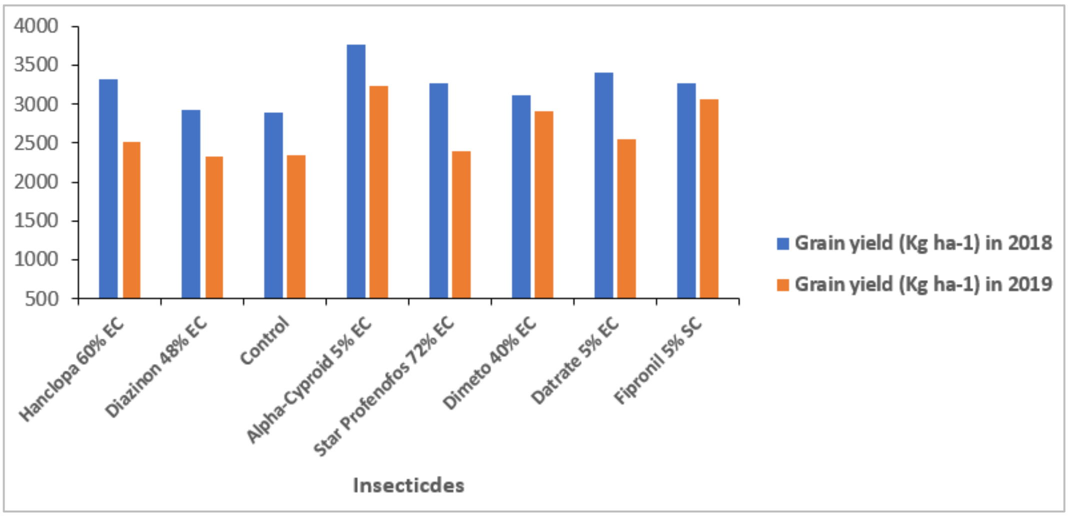

Figure 2. *Effect of insecticides on grain yield of rice in 2018 and 2019.*

Study results on effect of insecticides on stem borer population conducted by [15] showed significant difference on percent dead hearts in rice crop. Mean maximum percent of dead hearts (4.55%) were recorded on control plot followed by Chloropyrifos with 3.44% dead hearts which is in line with the current finding. While mean minimum percent of dead hearts were recorded on Lambda-cyhalothrin with 1.44% dead hearts.

Similarly, the effect of various insecticides against rice stem borer in grains yield (kg ha^{-1}) were observed statistically significant difference from each other treatments. The mean maximum grains yield was found in Lambda-cyhalothrin (1875 kg ha^{-1}), followed by Bifenthrin and Lufenuron with 1809.5 and 1806.6 kg ha^{-1} respectively, while the minimum grain yield was noticed in control plot (1789.7 kg ha^{-1}) [15] and this result is in conformity with our finding.

The findings of [15] on the effect of various insecticides against rice stem borer in number of 1000 grain weight also showed statistical variation among the cultivars. Mean maximum thousand grains weight were calculated in Lambda-cyhalothrin (12.53g), followed by Bifenthrin (12.15g), Lufenuron (11.98g) and Chloropyrifos (11.79g) respectively, whereas the minimum thousand grains weight (g) were found in control plot (11.2) and not in line with the current findings.

4. Conclusion and Recommendation

In this study, seven insecticides were tested for the control of rice stalk-eyed shoot fly under field conditions of the upland rice ecosystem at Pawe, northwest Ethiopia. The result revealed that all the test insecticides have significantly reduced the number of dead heart as compared to the control. However, Alpha-Cyproid 10% EC insecticide was superior among the test insecticides in reducing the number of dead heart. It exhibited the lowest number of dead heart and resulted in the highest grain yield (3503.50 kg ha^{-1}) with up to 34.04% yield gain over the control. Fipronil 5% SC was the second most effective insecticide. Dimeto 40% EC and Datrate 5% EC insecticides were also effective in dead heart reduction and gave a yield that was statistically similar to that of Fipronil 5% SC and can be considered as an alternative insecticide for the management of rice stalk-eyed shoot fly in the absence of Alpha-Cyproid 10% EC.

The present result suggests that twice application of Alpha-Cyproid 10% EC insecticide at the rate of 0.4 Lha^{-1} is effective for the management of rice stalk-eyed shoot fly in Pawe and other areas with a similar condition. In the future, additional research and regular evaluations of insecticides in the greenhouse is needed as an essential part of stalk-eyed fly management in rice production.

Abbreviations

FAO	Food and Agriculture Organization
m.a.s.l	Meters above sea level
RCBD	Randomized Complete Block Design
IRRI	International Rice Research Institute
ANOVA	Analysis of Variance
NDH	Number of Dead Heart

Acknowledgments

The authors would like to thank the Ethiopian Institute of Agricultural Research /EIAR/ for funding the budget to conduct the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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