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Research Article

Efficacy of commercially available insecticides against yellow stem borer (*Scirpophaga incertulas* Walker.)

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Abstract

Field research was conducted in PMAMP, (PIU) Jhapa, Nepal, Rice Zone against Yellow Stem Borer by using different chemical insecticides commercially available in Nepal to test their efficacy. The research was done in Randomized Completely Block Design (RCBD) with three replication, and seven treatment i.e., 6 chemical treatment namely Cartap hydrochloride 75SC, Thiamethoxan 25WB, Acetamiprid 20 SP, Chlorpyriphos 20 EC, Quinalphas 25 EC and Lambda Cyhalothrin 5 EC and one control for five months. It is concluded that Chlorpyriphos 20 EC is most effective in reducing the infestation rate of dead heart and white head. Similarly, the highest yield was observed in Chlorpyriphos 20 EC with 5.563 ton ha^{-1}.

Introduction

Rice is life obtained from paddy grain, and is a staple food (for more than two billion people) for people all over East, South, and South east Asia (Kundu et al., 2018; Dalvi et al., 2021). Rice (*Oryzae sativa L.*) is a perennial grass belonging to the family Poaceae/Graminae. There are about 23 species of rice, but only two are widely domesticated and commercially valuable which are *Oryzae sativa* (Asian rice) and *Oryza glaberrima* (African rice). In terms of area harvested, rice is second only to wheat in the world, but in terms of importance as a food crop, rice provides more calories per hectare than any other crop (Rath et al., 2020). Rice crop is extremely versatile and adaptive with a temperature in between 21˚C to 37˚C. It can be grown in altitude ranging from sea level to 3000 m above sea level (Rath et al., 2020). Rice is cultivated in three agro-ecological regions in Nepal from Terai, to Himalayan regions (67 to 3050 masl), and three major production environments: irrigated, rain-fed low land, and upland. The most damaging rice pests are stem borers. Three families; Noctuidae, Diopside and Pyralidae, have been documented as rice stem borers. The pyralidae borers possess high host specificity. In Asia, the most destructive and widely distributed are *Scirpophaga incertulas*, *Chilo suppressalis*, *Sesamia inferens*, *Scirpophaga innotata*, and *Chilo polychrysus*. In Asia, *Chilo suppressalis* and *Scirpophaga incertulas* cause a damage of 5-10% of the total rice crop (Iqbal, 2021).

Among the various strategies adopted to combat the pest of rice, insecticides are the first

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line of defense (Chormule et al., 2014). Chemical insecticides are still effective methods to control insect pests (Singh et al., 2015). The insecticide thiamethoxam which is active against many sucking and biting insects, Lambda cyhalothrin, is a mixture of highly active isomers of cyclothrin, it is a non-systemic insecticide which acts on the nervous system of the insects, by disrupting the function of neurons by interaction with the sodium channel (Teló et al., 2015). In India, a study with thiamethoxam and lambda cyhalothrin insecticides applied to the aerial parts of rice plants at both the recommended rate and twice the recommended rate found no residues in the grains (Barik et al., 2010).

The main objective of this research is to determine the efficacy of the commercially available insecticides against Yellow Stem Borer. Other Specific objectives are to study the effect of insecticides on dead heart and white head damage, and also to study the effect of insecticides on plant height, filled grain, unfilled grain, test weight and yield of rice.

Materials and methods

Experimental site and time period

The Experimental research was conducted at Kachankawal-6, Baniyani, Jhapa at farmer field of Mr. Dilli Prasad Nepal, Baniyani, Jhapa which is situated in Priovince-1, Jhapa district lies in between 26^0 26'12.3" N latitude and 88^0 2' 33.1" E longitude with altitude of 61 meter above sea level. The experiment was conducted from 11th February to 17th June 2022.The experiment was carried out in Hardinath-1 which is most common variety grown in this region.

Layout and design of experiment

The experiment was carried in spring season in early variety of rice i.e. Hardinath-1 in Randomized Complete Block Design (RCBD) consisting 6 chemical treatments and one control, these treatment were replicated three times each. The total area of the field is 340 m^2 with individual plot size of 12 m^2 in which plant to plant, and row to row spacing us 0.2 m and 0.2 m respectively.

Cultivation practices

Seed rate and seed treatment

The seed was treated with 1 packet of salt before sowing on nursery bed. Generally, 2.5 kg seed per katha seed rate was preferred because the germination percentage is low due to low temperature.

Nursery bed preparation and seed sowing

The seed bed was prepared by ploughing the field and the soil was made pulverized and labelled with the help of spade. All the weeds of the field were removed. The seed was sown in a prepared nursery bed. The wet nursery bed was made of plot size 6m*4m (24 m^2). The recommended dose of well-decomposed Farm Yard Manure (FYM) and 160:60:45 gm of Urea, DAP, MOP were applied in a nursery bed. The treated seed was shown. The seed was broadcasted above the film of water layer above the wet bed.

Main field preparation and transplantation

The main field was ploughed and well decomposed FYM was applied 7 days before transplanting. The field was irrigated before transplanting to suppress the weed and other materials. One day before transplanting, final rotavator and final layout of the experiment was carried out and all the plant debris were collected and removed from the field. The land was ploughed and puddle with standing water using a rotavator. The field was levelled with the help of spade, rake and hoe. The transplantation of 31 days old seedlings was transplanted in well prepared land. Two seedlings were transplanted per hill with 0.2*0.2 m row to row and plant to plant distance.

Intercultural operation

Intercultural operation helps in proper growth and development of rice crop. Following intercultural operation were performed.

Bunds making

Buds are made along the blocks to prevent the movement of flow of water from one block of treatment to others. The bunds are made 2 days after transplanting and regularly maintenance of bunds was done.

Fertilizer application

A day before seedling transplantation, a half dose of nitrogen and a full dose of phosphorus and potash were applied.2 kg of urea (first split dose), 3 kg of DAP and 2 kg of MOP were used as a basal dose as per general recommendation (100:50:50 kg NPK ha^{-1}). The second and third doses of urea were applied at the early tillering, and panicle initiation stage respectively. Proper irrigation was done. Regular irrigation was done after 5 days interval in case of low rainfall. Irrigation was stopped up to 2 days after spraying the insecticides. Field was dried out at before harvesting.

Weeding

Hand weeding was done at 30 days after transplanting and 60 days after transplanting.

Application of treatment

Treatments were applied on 37th days after transplanting (21 April 2022) during which dead heart percent was above the Economic Threshold Level (ETL) and 60th days after transplanting at 23 days interval. A knapsack sprayer was calibrated to determine the amount of spray solution per plot. A total of 4 liter of insecticidal solution was prepared and sprayed in each respective plot according to their recommended dose (Table 1). A four liter of tap water was sprayed in each control plot.

Table 1. Treatment detail used in the research

S.N.	Chemical Composition	Trade Name	Treatment	Dose per plot (gm/ml formulation per plot)	Dose (g a.i. ha^{-1})	Volume of water (L)
1	Acetamiprid 20% SP	Dhanpreet	T3	0.6	100	4
2	Cartap hydrochloride 75% SG	Mortar	T6	1.2	750	4
3	Chlorpyriphos 20 % EC	DhanVan20	T2	2.4	400	4
4	Quinalphos 20% EC	Krush	T1	7.8	1300	4
5	Lambda cyhalopthrin 75%SG	Wrestler	T4	0.4	250	4
6	Thiamethoxam 25% EC	Hawk eye	T5	0.48	100	4
7	Untreated (Control)		T7			4

Harvesting and threshing

Manual harvesting was done, using a traditional sickle after (80-90) % plants maturity. The center 1 square meter was marked and harvested separately in each plot. The moisture content on rice grains during harvesting was from 17 - 24.8%, which was measured by using a moisture meter. The harvested rice head was left and sun-dried for a day. The grain was cleaned by winnowing and the weight was measured by using an electric weighing balance machine of each plot. Care was taken during threshing, drying and cleaning of grain. For filled and unfilled grains data collection panicles from 10 randomly plants were taken from each blocks or plots.

Observation

Ten plants were randomly selected from each plot excluding border plant and tagged for vegetative, reproductive and borer damage assessment.

Vegetative Stage

From each plot, total number of tillers were counted on sample plant at 37th days after transplanting and 60th days after transplanting. The height of plant was taken at vegetative and reproductive stage at 37th days after transplanting and 85 days after transplanting.

Damage assessment

a. Dead heart

Total number of tiller and infected tiller (dead heart) were counted 3 times on sample plant at 7 days interval starting a week after first spray and dead heart percentage was calculated by

Dead Heart (DH%) =

$$\frac{\text{Number of dead hearts(DH)}}{\text{Total number of tillers}} \times 100$$ (Omprakash et al., 2017)

b. *White heads*

Total number of white head and tiller with panicle were counted 3 times on sample plant on 7 days interval after second spray and white head percentage was calculated by

White Head (WH%)

$$= \frac{\text{Number of white heads(WH)}}{\text{Total number of tillers with panicle}} \times 100$$

(Omprakash et al., 2017)

Reproductive Stage

Yield: From each plot, $1m^2$ including sample plant was harvested, threshed at 91 days after transplanting on 14th June 2022, and its moisture content was measured. The yield of grain at standard moisture was calculated by

Grain yield

$$= \frac{\text{Harvest yield x } (100 - \text{Harvest moiture})}{(100 - \text{Standard moisture})} \; x\ 100$$

The yield per plot was converted into ton ha^{-1}.

Test weight, filled and unfilled grain percentage

A sub sample was taken from each harvested plot and sun dried until moisture content reached to 12% and then 1000 weight grains were counted, and their weight was taken. From 1000 grain, filled and unfilled grain was counted, and filled and unfiled grain percentage were calculated by

Filled grain % =

$$\frac{\text{Total number of grain (1000 grain)} - \text{total number of filled grain}}{\text{Total number of grain (1000 grain)}} \times 100$$

Unfilled grain % =100- filled grain percentage.

Data analysis

The data obtained from the field experiments were arranged in MS-Excel (2010) and the data were analyzed by using GEN-STAT software (15th edition). After converting to square root transformation, the mean dead heart and white head, as well as the percentage of filled and unfilled grains, were statically analyzed and were converted into arch sign transformation as suggested by Gomez & Gomez (1984). The critical difference values were calculated at 5% probability level and the treatment mean values of the experiment were compared using Duncan's Multiple Range Test (DMRT).

Results

Infestation of dead heart and white head

Among the different insecticidal treatment, efficacy against Yellow stem borer was found to be more effective with Chlorpyriphos 20 % EC with 5.8 % mean dead hearts, followed by Thiamethoxam 25 % EC with 7.800 % mean dead heart. Generally, the efficacies of four other insecticides were in order of their effectiveness lambda Cyhalothrin 5% EC, Quinalphos 25 % EC are in par with each other with the mean dead hearts of 8.467% and 8.633% respectively. Acetamiprid 20 % SP is least effective among the chemical treatment with 11.567 percent mean dead heart. Overall the highest infestation was seen in the control with 12.967% mean dead heart.

The treatment chlorpyriphos 20% EC was highly effective at reducing yellow stem borer at white heads with 3.212 % mean white head and par with lambda Cyhalothrin and Thiamethoxam 25 % EC with 4.230 % and 5.15 % mean white head respectively. However, the highest infestation was observed in Acetamiprid 20 % SP (9.209 %) followed by Control (9.579%) and par with each other.

Table 2. Efficacy of insecticides against yellow stem borer after spray in spring rice

Treatments	Mean dead heart (%)	Mean white head (%)
Chloropyriphos 20% EC	5.80[a] (2.52)	3.21[a](3.71)
Thiamethoxam 25% EC	7.80[ab] (2.87)	5.15[a](5.65)
Lambda cyhalothrin 5% EC	8.46[bc] (2.99)	4.23[a](4.73)
Quinalphos 25% EC	8.63[bc] (3.00)	5.86[ab](6.36)
Cartap hydrochloride 75% SG	10.33[cd] (3.28)	7.13[ab](7.63)
Acetamiprid 20% SP	11.56[de] (3.47)	9.20[b](9.70)
Control	12.96[e] (3.66)	9.57[b](10.07)
Mean	9.38	6.34
$LSD_{0.05}$	2.177	3.698
s.e.d.	0.99	1.697
CV%	13	30.8
Pr>F	***	*

The values are the average of three replications performed on three different days of observation (7, 14 and 21 days after Spraying); CV: Coefficient of variation; ***: Significant at 0.1% level of significance; *: Significant at 5% level of significance; s.e.d.: Standard error difference; By DMRT, values with the same letters in a column are not significantly different at the 5% level, and figures in parenthesis represent square root transformation values.

Grain yield and yield attributing characters

Grain yield

Statistically significant variation was recorded in terms of yield/hectare of rice due to different chemical insecticides under the present trial (Table 3).

It was observed that the highest yield was recorded from Chlorpyriphos 20 EC (5.56 ton ha^{-1}) which was closely followed by Thiamethoxam 25WG (5.52 ton ha^{-1}). Further, this was followed by Quinalphos (5.35 ton ha^{-1}), and par with each other. The lowest yield/hectare was observed from control treatment (3.730 ton ha^{-1}). In the case of increase percent over control, the highest value was observed from Chlorpyriphos 20EC (49.14 %) and the lowest was observed on Acetamiprid 20 SP (21.55%).

Yield attributing characters

Test weight (1000 grain weight)

Test weight is the weight of 1000 grains of rice. Test weight of rice showed statistically significant differences due to different insecticides under the present trial (Table 3).

Data revealed that the highest test weight was recorded from Chlorpyriphos (22.13 g) which was statistically similar to Thiamethoxam 25 % EC (19.95%) and Lambda cyhalothrin 5% EC (18.06 g), whereas Quninalphos 25% EC (19.37%) are par with each other and closely followed by Emamectin benzoate 5 SG (19.50g), Cartap hydrochloride 75% SG (19.00 g) and Acetamiprid 20 % EC whereas the lowest test weight was observed from Control (12.70 g) (Table 3).

Filled grain

The number of filled grains/panicles of rice showed statistically significant variation due to different insecticides (Table 3).

It was observed that the highest number of filled grains was recorded from Chlorpyriphos 20% EC (82.75%) which was statistically similar to Thiamethoxam 25 % EC (82.08%), Lambda cyhalothrin (81.08%), Quinalphos 25 % EC (81.08%) which are at par with each other, Cartap hydrochloride 75% SG (80.80%) and Acetamiprid 20% EC (80.42%) whereas, the lowest number of filled grains/panicle was recorded from control (71.83%)

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Unfilled grain

Statistically, significant variation was recorded in terms of unfilled grains of rice due to different insecticides (Table 3).

Data revealed that the lowest number of unfilled grains/panicle was recorded from Chlorpyriphos 20 EC which was followed by Thiamethoxam (17.92%), Lambda cyhalothrin 5 EC (18.92%), Quinalphos 25 EC (18.92%)

which are par with each other whereas the highest unfilled grains/panicle was recorded in Control (28.17%).

Plant height

There was no significant difference in plant height among various tested insecticides. However, highest plant height was observed in Thiamethoxam 25 % EC (96.90 cm) followed by Acetamiprid, Cartap hydrochloride with 93.30, 90.53 cm respectively. Different environment factor like temperature, rainfall and fertilizers dose affect the height of the plant (Table 3).

Table 3. Effect of different insecticides on plant height, filled grains, unfilled grains, test weight, yield in spring rice

Treatments	Mean plant height (cm)	Filled grain (%)	Unfilled grain (%)	Test weight (gm)	Yield (t/ha)	% increase in yield over control
Chlorpyriphos 20% EC	89.17	82.75[b] (65.49)	17.25[a] (24.45)	22.13[c]	5.56[b]	49.06
Thiamethoxam 25% EC	96.90	82.08[b] (64.15)	17.92[a] (24.81)	19.95[b]	5.52[b]	47.98
Lambda cyhalothrin 5% EC	89.17	81.08[b] (64.15)	18.92[a] (25.72)	19.37[b]	5.10[b]	36.72
Quinalphos 25% EC	89.60	81.08[b] (64.15)	18.92[a] (25.73)	19.56[b]	5.35[b]	43.43
Cartap hydrochloride 75 % SG	90.53	80.80[b] (63.96)	19.17[a] (25.91)	19.00[b]	5.09[b]	36.46
Acetamiprid 20% SP	93.30	80.42[b] (63.67)	19.58[a] (26.20)	18.06[b]	4.53[ab]	21.44
Control	89	71.83[a] (57.97)	28.17[b] (31.91)	12.70[a]	3.73[a]	0
Mean	91.1	80.01	19.99	18.68	4.99	
$Lsd_{0.05}$	8.86	7.276	6.222	2.868	1.806	
s.e.d	4.07	2.365	2.365	0.989	0.49	
CV %	5.5	3.6	14.5	6.5	12.2	
Pr>F	ns	*	*	***	*	

The values are the average of three replications performed on three different days of observation (7, 14 and 21 days after Spraying); CV: Coefficient of variation; ***: Significant at 0.1% level of significance; *: Significant at 5% level of significance; s.e.d.: Standard error difference; By DMRT, values with the same letters in a column are not significantly different at the 5% level, and figures in parenthesis represent arc sine transformation values.

Discussion

Stem borers are polyvoltine, but the number of generations per year is determined by environmental factors (primarily temperature, rainfall, and crop availability (Dalvi, et al., 2021). The female lays disc-shaped eggs near the upper surface of the leaf. The eggs are generally on a mass containing 50-80 eggs, which is covered with pole brown hairs from anal tuft of female moths to avoid parasitism (Ali & Shah, 2022). The newly hatched larvae is pale yellow with dark brown head and prothoracic shields. It dangles from a silken thread, falls into the water, and swims freely to reach an adjacent plant. Before pupation, the mature larva webbing covers the exit hole, then forms a white silken cocoon within the stem and pupates. The role of the larva is to grow in size built of energy, reserves and disperse from plant to plant. Large larva become larger moth, which lay more egg (Khan, 1991). Pupation takes place inside the rice stem, straw or stubble. The threshold temperature for pupal development is 15-160C. A pupa developed into an adult in 6-8 days depending upon weather condition. Threshold temperature for pupal development is 160C (Khan, 1991). The pupal stage lasts a week in areas when only one rice crop is grown in a area the borer occurs in 1-4 distinct generation called broods but in area where rice is grown continuously they occurred throughout the year in overlapping generation (Chaudhary & Khush, 1984). When the adult emerges from the stem through the exit hole, it moves to other plants where it lays eggs and continues to cause damage to rice crops. The female of yellow stem borer are highly phototropic and attracted to light. Most borer species are capable of flying only a short distance; however, they can travel 8–16 km if carried by wind (Muralidharan & Pasalu, 2006).

Figure 1. Egg laid on cluster, creamy white, oval and flat

Figure 2. Larva 20 mm long, yellowish in color

Figure 3. Pupa pale to dark brown color

Figure 4. Adult forewings of female is pale yellow to dark yellow towards the tip, one black spot on each wings

Field experiment conducted by Sawant et al. (2019) found that the treatments Chlorpyriphos 75 WDG @533 g/ha and Chlorpyriphos 75% WDG @500 g/ha were found to be superior in reducing the incidence of stem borer (*Scirpophaga incertulas*) over the other treatments. Present findings are in conformity with the findings of Prasad et al. (2005) who reported that chlorpyriphos 10 G @ 0.75 kg a.i./ha were found to be the most effective with infestation of 3.65 percent, in comparison to 8.1 per cent white head in untreated control. The present findings shows that chlorpyriphos 20% EC shows minimum mean dead heart and white head with 5.8 % and 3.212% respectively. The efficacy of chlorpyriphos 20 EC against stem borer in the present studies are in accordance with the earlier finding of Roshan (2006). Sarao and Mahal (2008) reported that cartap hydrochloride followed by monocrotophos and chlorpyriphos were proved to be most effective. Pallavi and Sharanabasappa (2018) also proved that Lambda cyhalothrin is effective over control.

Conclusion

Chlorpyriphos 20 EC is the most effective treatment in reducing the infestation of dead hearts and white heads with 5.800% and 3.212% respectively and it was par with Thiamethoxam 25 WG. The highest yield was recorded in Chlorpyriphos 20 EC followed by Quinaphos, Thiamethoxam, Lambda cyhalothrin. At the end this study concludes that the insecticides Chlorpyriphos 20 EC and Thiamethoxam 25 EG would be recommended for the farmers to control the yellow stem borer.

Author’s declaration

The authors declare no conflicts of interest. All authors contributed equally in all stages of preparation of this manuscript. Similarly, the final version of the manuscript was approved by all authors.

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