Performance of various pesticides against Yellow stem borer, Scirpophaga incertulas (Walker) of Basmati rice and effect on yield in Northern India

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Research Article

Keywords: Pesticides, Rice, Yellow stem borer and Yield

DOI: https://doi.org/10.21203/rs.3.rs-284878/v1

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Abstract

The present investigation was based on the management of Yellow stem borer which is a major pest of Basmati rice crop in India. All the treatments were applied to control this pest when it reached on its ETL level. The data recorded one day before of first spray and 3, 7, 10 days after of each spray. The observation revealed that all the treatments were found significantly superior over untreated control. Among the all treatments Fipronil 5 SC was found most effective followed by Imidacloprid 17.8 SC, Cartap hydrochlorid 4 G. Among the bio-pesticides B. bassiana was most effective after the chemical pesticides followed by M. anisopliae and V. lacani. The field treated with fipronil 5 SC produced the highest grain yield (38.35 q/ha) and Imidacloprid 17.8 SC was placed on second place with 37.26 q/ha grain yield followed by Thiamethoxam 25 WG (36.05q/ha) and Cartap hydrochloride 4G (33.87 q/ha).

Introduction

Rice (Oryza sativa Linn.) belongs to the family-Poaceae, is that the major cereal crop which is providing about 80 per cent of the calories to over 2 billion people of Asian. Rice grown about 44.50 M ha with production of 115.63 Mt in India (Anonymous, 2019). It's cultivated all told the tropic, sub-tropic and temperate country of the everywhere world. It's grown from 430 N latitude to 390 S and up to the elevation of two,500 m. Rice is two type aromatic and non aromatic. Out of those aromatic rice contributes a tiny low portion in rice production. Rice is cultivated besides Pakistan, Iraq, Iran, Afghanistan, Bangladesh, Myanmar, Indonesia, and Vietnam together with India. Haryana, Punjab, Uttarakhand and Western U. P. are the most basmati rice producing state of India (Kumar and Singh, 2020). Aroma with super fine kernels is that the most significant feature of the Basmati rice. Basmati emits specific aroma within the field at the time of harvesting, in storage, during milling, cooking and eating (Bharti et al., 2018). Rice is that the major staple food for half of the globe. It's important crop because its nutritional further as commercial value as 100 g of rice supplies 365 kcal energy, 0.12 g sugar, 7.12 g protein 1.3 g dietary fiber and traces of thiamine, riboflavin, zinc, calcium, iron, manganese (Anonymous, 2010). So it's necessary to extend the productivity of rice to fulfill the food requirement of the growing population of the planet. But there are various factors liable for the reduction of rice yield together with many of the diseases and bug pest. One among the most reasons for the low productivity of rice is insect-pests, diseases and weeds. (Kumar et al., 2019)

Among all the insects, Yellow stem borer is one of the foremost important pest of rice which is chargeable for the severe economic losses under the local conditions. Infestation of this insect occurs from the seedling to till harvest of the crop. In India, the losses causes by various insect pests are reported to the tune of 55.12 million rupees which successively workout to 18.16 percent of total loss. Out of this, 20 to 30 per cent damage is barely done by yellow stem borer (Lal, 1996). After the emergence of larvae from the egg mass it enters into the tiller and begin feeding within the tiller thanks to this the tillers dries up and appears in brownish colour leading to “dead hearts” and further growth of the tiller. During reproductive stage, whitish and chaffy panicles are the characterized damage done by this insect known as “white ears”. Use of insecticides is one among the foremost effective management tools now days which is principally employed by the Indian farmers. It's also a crucial component of IPM besides biological and cultural methods and other hand indiscriminate use of assorted chemicals also chargeable for reduced biodiversity of natural enemies, induce outbreak of secondary pests and contaminate eco-system (Singh 2000). Keeping mind the concept of agro ecosystem the research program was undertaken to analyze the effectiveness of various approaches of chemical and biological control against Yellow stem borer, Scirpophaga incertulas (Walker). Various chemicals is also toxic for the animal, human and other living organism so it's important to experimentally determine a pesticide that fit well in pest management programme. Hence, it's proposed to gauge the sphere efficacy of certain pesticides against yellow stem borer of rice. The small print of used pesticides are given in Table no. 1.
Materials And Methods

Experimental details

The field experiment was conducted at Crop Research Centre of the University during Kharif-2018 and this experimental site is situated 29°04’ N latitude and 77°42’ E longitudes at an altitude of 237 meter above the mean water level (MSL). This region falls under the north-western plains sub-region of upper Gangatic zone in Western Uttar Pradesh. The experiment was laid move into randomized block design (RBD) with nine treatments with three replications including untreated control. Pusa Basmati-1 Variety was selected for the experimental study. The seedlings which were 25 days old, transplanted within the main plot with size of 5 x 4 m² at CRC.

Pesticides application- All the treatments were applied twice at the time of peak post population, first treatment given after 50 days followed by second treatment at 82 days after transplanting with a knapsack sprayer fitted with hollow cone nozzle using 500 L of spray fluid per ha. The treatments imposed are described in Table 1.

Method of observations

Pre-treatment observations were recorded one day before of first pesticides application from the ten randomly selected hills, while post treatments observations were recorded on 3rd, 7th and 10th days after on each pesticides application. The number of dead hearts counted from ten randomly selected hills in each plots. The proportion of dead hearts were puzzled out by using the formula-

$$Pd (\%) = \frac{Nd}{Nt} \times 100$$

Where $Nd$ are the number of dead hearts and $Nt$ is the total number of observed tillers in 10 hills. $Pd$ is the dead heart percentage of $Nd$ and $Nt$.

Yield Assessment

For assessing the grain yield weight of healthy and damaged grains were recorded from each plot and converted in to q / ha with the assistance of following formula-

Grain yield (q/ha) = \frac{\text{Weight of grains in kg/plot} \times 10000}{\text{Plot area in m}^2}

The cost: benefit ratio was also calculated by dividing net profit over control by total cost (insecticides and labour charges etc). The formula for Cost Benefit ratio is-

$$\text{Cost Benefit Ratio} = \frac{\text{Cost of increased yield (Rs/ha)}}{\text{Total cost of treatment (Insecticides + Labour charge etc.)}}$$

Statistical analysis

The data recorded during the courses of investigation were subjected to statistical analysis using analysis of variance technique (ANOVA) for randomized block design as suggested by Panse and Sukhatme (1978). The data were recorded transformed necessary as and when required. Slandered error of mean in case, critical difference only at significantly cases were computed at 5 percent level of probability as under-
\[ \text{SE(m)} = \sqrt{\frac{\text{EMSS}}{r}} \]

Where, \( \text{SE(m)} \) = Standard error of mean

\( \text{EMSS} \) = Error mean sum of square

\( R \) = number of replication

The critical difference at 5 per cent level of probability was puzzled out to check treatment mean wherever ‘F’ was significant

\[ \text{Critical difference} = \text{SE(m)} \pm x\sqrt{\text{t}} \times (\text{at error degree of freedoms}) \]

The data recorded during the course of investigation, were also analyzed with the assistance of computer software “OPSTAT1” developed by O.P.Sheoran.

**Results**

**Efficacy of insecticides on Yellow stem borer after first spray**

**I. Pre-treatment**

One day before of treatment application the data were taken from the plot, revealed the percentage of Dead Hearts within the field. The range of DHs per cent varied from 5.79 to 6.49. It was showing that it was statistically non-significant difference in numerous treatments and indicating as approx. uniform damage in all treatment of the field. Data represented in Table-2 and Figure-1&2.

**II. Post Treatment**

**After 3 days**

Data recorded on 3\(^{rd}\) day after the spray and it was indicate that all the treatments were found significantly superior over untreated control and only chemical pesticides reduced the damage of *Scirpophaga incertulas*. The bottom damage was observed in the plot which was treated by Fipronil 5 SC (5.21 %) and significantly superior to Imidacloprid 17.8 SC (5.51 %) followed by Cartap hydrochloride 4 G (5.62 %). The next effective order of pesticides were Lambda cyhalothrin 5 EC, Thiamethoxam 25 WG, *B. bassiana*, *M. anisopliae* and *V. lacani* while the reduced damage were 5.70 %, 5.84%, 6.14%, 6.29% and 6.35%, respectively. Highest damage caused by *Scirpophaga incertulas* found in untreated control which was 6.53%.

**After 7 days**

After seven days of spray, the minimum damage was observed within the plots which is treated with Fipronil 5 SC was again found best and recorded lowest damage was 3.29 % and proved best treatment. It was significantly superior to rest of the treatments. After Fipronil 5 SC, Imidacloprid 17.8 SC (3.95 %) was the second most effective pesticide followed by Cartap hydrochloride 4 G (4.69 %), Lambda cyhalothrin 5 EC (5.00 %), *Thiamethoxam 25 WG* (5.25 %). The subsequent effective bio pesticides order was *Beauveria bassiana*, *M. anisopliae* and *V. lacani* while the reduced damage were 5.61 %, 5.96 % and 6.07%, respectively. Highest damage caused by insect found in untreated control which was 6.68 %.
After 10 days

Data recorded on the 10th day after spray, it was found that each one insecticides were found effective and significantly superior to untreated control. I Fipronil 5 SC was effective and gave best performance with the less amount of damage (2.37 %) and it was followed by Imidacloprid 17.8 SC with 2.99 % DHs. The another treatments like Cartap hydrochloride 4 G, Lambda cyhalothrin 5 EC, Thiamethoxam 25 WG, B. bassiana, M. anisopliae and V. lacani were recorded 3.79%, 3.94%, 4.33%, 4.51%, 4.71% and 5.94%, respectively. Highest damage was recorded in untreated control (6.81 %)

Efficacy of insecticides on Yellow stem borer after second spray

The trend of effectiveness of treatment was almost similar as in the first application on reduction of damage was recorded after second spray and all treatments were found effective than untreated control.

After 3 days

The data taken from the experimental treated plots after three day of spray indicated that all the treatments were found significantly superior over the untreated control. Plots treated with Fipronil 5 SC observed as the best treatment and the damage was lowest (4.86 %) among the all treatment which was followed by Imidacloprid 17.8 SC (4.99 %). The next effective order was Cartap hydrochloride 4 G (5.05 %) > Lambda cyhalothrin 5 EC (5.14 %) > Thiamethoxam 25 WG (5.37 %) > B. bassiana (5.40 %) > M. anisopliae (5.49 %). V. lacani was least effective against Yellow stem borer with 5.86 % DHs. Highest damage was recorded in untreated control (7.61 %).

After 7 days

After 7th day of second application, Fipronil 5 SC was again found most effective and recorded lowest damage with 3.31 % DHs in the plot. The next effective treatment was Imidacloprid 17.8 SC (3.84) followed by Cartap hydrochloride 4G (4.09), Lambda cyhalothrin 5 EC (4.30 %) and Thiamethoxam 25 WG (4.58 %). In bio pesticides B. bassiana was the most effective after the chemical pesticides with 4.96 % DHs followed M. anisopliae (5.13 %), and V. lacani (5.30 %) were come in this order. After 7 day of spray, Fipronil 5 SC was the best treatment against YSB while V. lacani was the least effective treatment among all the treatment. 7.88% DHs was recorded in the untreated control.

10th Day after spray

After 10th day of spray, data revealed that Fipronil 5 SC again found effective and it was best treatment among all the treatment of the field experiment with 2.03 % DHs followed by Imidacloprid 17.8 SC with 2.40 % DHs in field and it was also statically at par with better treatments. On 10th day of application, the order of effectiveness was Cartap hydrochloride 4 G (3.03 %), Lambda cyhalothrin 5 EC (3.47 %), Thiamethoxam 25 WG (3.62 %), B. bassiana (3.95 %), M. anisopliae (4.13 %), and V. lacani (4.42 %), respectively. Highest damage was recorded in untreated control (8.14 %).

In the present investigation Fipronil 5 SC was found most effective against the damage of yellow stem borer, which was already reported by Kakde and Patel (2019) and also investigated that Cartap hydrochloride 4 G is less effective after Fipronil against the yellow stem borer's damage that is agreed by Singh et al. (2017) and Lai (2006). Seni and Nail (2017) also revealed that Fipronil 5 SC was the most effective followed by imidacloprid. Sulagitti et al., (2017) and Kumar and Kumar (2017) revealed that B. bassiana and M. anisoplea are the effective among the bio-pesticides for management of yellow stem borer. In the present findings V lacani also gave better result. The above and previous studies on the similar work strongly supporting to this research work.
Yield Assessments

On the basis of all expenses in the experiment like insecticides, cost of Seed, labour and Irrigation charges etc. and the increased income over control due to the treatments rice yields; Highest yield was obtain in the plot which was treated with Fipronil 5 SC (38.35 q/ha) followed by Imidacloprid 17.8 SC (37.26 %). We calculated the cost benefit ratio which is represented in the Table-3 and Figure-3. All the treated plot resulted significantly higher production ranging between 32.53 to 38.35 q/ha than untreated control with 26.60 q/ha. yield. The cost benefit ratio of Imidacloprid 17.8 SC is 1:7.83 followed by Thiamethoxam 25 WG (1:7.59) and Fipronil 5 SC (1:6.66). Here, This fipronil 5 SC is placed on third because of its cost while provide highest production in term of q/ha. The Cartap hydrochloride 4G and Lambda cyhalothrin 5 EC are lower in production because of their efficacy against some other insect pest viz. BPH, Gall midge, WPH and others.

From the present study, higher grain yield and net profit were recorded in the treatment Imidacloprid 17.8 SC @ 200ml/ha. which is agreement with the finding of Sangamithra et al., (2018) and Mishra et al., (2009). The best cost benefit ratio in the present finding was recorded with the treatment Imidacloprid 17.8 SC @ 200ml/ha (1:7.83) followed by Thiamethoxam 25 WG @ 100gm/ha (1:7.59) this finding was partially similar with the finding of Kumar and Kumar (2017).

Conclusion

The observation of average damage on per cent dead heart caused by yellow stem borer was taken one day before first application and after 3, 7, 10 days of each spray. The observation revealed that Fipronil 5 SC (T3) followed by Imidcloprid 17.8 SC (T1) and Cartap hydrochloride 4 G (T5) were at par while other treatments also were found at par over untreated control but they significantly showed the less damage over control.

The effectiveness of treatments determined in term of grain yield was Fipronil 5 SC followed by Imidacloprid 17.8 SC and among the biopesticides, B. bassiana was most effective in term of yield followed by M. anisopliae (34.65 q/ha). The highest Dhs percent was observed in the plot which was treated by V. lacani and least DHs per cent was recorded in the plot treated with Fipronil 5 SC.

Declarations

Conflict of interest-On behalf of all authors, the corresponding author states that there is no conflict of interest.

Acknowledgement-The author is very much thankful to Dr. Hem Singh, Associate Professor (Entomology) for his guidance along with this the author also expresses his gratitude to the SVP University of Ag. & Tech. and ICAR (Indian Council of agricultural research) for providing all the required facilities during this research work.

Finencial Funding-This study was funded by ICAR (Indian council of agricultural research) and S. V. P. University of Ag. & Tech., India.

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**Tables**

**Table 1: Treatment details**
| Treatment No. | Name of treatment with formulation | Trade Name | Dose | Source |
|---------------|----------------------------------|-----------|------|--------|
| T₁            | Imidacloprid 17.8 SC             | Immediate | 200 ml/ha | BR Agrotech Ltd, Rajendra Place, New Delhi |
| T₂            | Thiamethoxam 25 WG               | Savor     | 100 gm/ha | Coromandal Agrico Pvt. Ltd., Sikandrabad, U.P. |
| T₃            | Fipronil 5 SC                    | Regent SC | 1000 ml/ha | Bayer Crop-Science Ltd, Bari Brahmana, J. & K. |
| T₄            | Lambda cyhalothrin 5 EC          | Lambda Gold | 500 ml/ha | Indian Crop Chemical Pvt Ltd., East Mumbai, Maharashtra |
| T₅            | Cartap hydrochloride 4 G         | Vat 4G    | 750 gm a.i./ha | Meghmani Organics Ltd., Bharuch, Gujrat |
| T₆            | Beauveria bassiana 2 x 10⁹ c.f.u./gm | -     | 2.5 kg/ha | Biocontrol laboratory of S.V.P.U.A.& T. Modipuram, Meerut |
| T₇            | Metarhizium anisopliae 4.7 x 10⁸ c.f.u./gm | -     | 2.5 kg/ha | Biocontrol laboratory of S.V.P.U.A.& T. Modipuram, Meerut |
| T₈            | Verticillium lacani 2 x 10⁸ c.f.u./ml | Green Verticill | 2.5 l./ha | Greenlife Biotech Laboratory, Coimbatore, Tamilnadu |
| T₉            | Untreated                        | -         | -    | -      |

Table 2: Effect of treatments against Yellow Stem Borer, *Scirpophaga incertulas* (Walker) following first application
| Treatment | Treatments name with formulation | Dose/ha | Dead Heart (%) After 1st Spray | Dead Heart (%) After 2nd Spray |
|-----------|----------------------------------|---------|-------------------------------|------------------------------|
|           |                                  |         | DBS 3 DAS 7 DAS 10 DAS       | 3 DAS 7 DAS 10 DAS          |
| T₁        | Imidacloprid 17.8 SC             | 200 ml/ha | 6.28 (14.50) 5.51 (13.57) 3.95 (11.46) 2.99 (9.95) | 4.99 (12.89) 3.84 (11.28) 2.40 (8.77) |
| T₂        | Thiamethoxam 25 WG               | 100 gm/ha | 5.99 (14.15) 5.84 (13.97) 5.25 (13.23) 4.33 (11.98) | 5.37 (13.96) 4.58 (12.35) 3.62 (10.96) |
| T₃        | Fipronil 5 SC                    | 1000 ml/ha | 6.19 (14.40) 5.21 (13.17) 3.29 (10.45) 2.37 (8.78) | 4.86 (12.72) 3.31 (10.45) 2.03 (8.18) |
| T₄        | Lambda cyhalothrin 5 EC          | 500 ml/ha | 5.92 (14.07) 5.70 (13.80) 5.00 (12.91) 3.94 (11.44) | 5.14 (13.09) 4.30 (11.94) 3.47 (10.72) |
| T₅        | Cartap hydrochloride 4 G          | 750 gm a.i./ha | 6.33 (14.56) 5.62 (13.68) 4.69 (12.50) 3.79 (11.21) | 5.05 (12.96) 4.09 (11.63) 3.03 (10.00) |
| T₆        | Beauveria bassiana 2 x 10⁹ c.f.u./gm | 2.5 kg/ha | 5.79 (13.92) 6.14 (14.33) 5.61 (13.67) 4.51 (12.24) | 5.40 (13.43) 4.96 (12.86) 3.95 (11.45) |
| T₇        | Metarhizium anisopliae 4.7 x 10⁸ c.f.u./gm | 2.5 kg/ha | 6.49 (14.76) 6.29 (14.51) 5.96 (14.12) 4.71 (12.49) | 5.49 (13.55) 5.13 (13.05) 4.13 (11.73) |
| T₈        | Verticellium lacani 2 x 10⁸ c.f.u./ml | 2.5 l./ha | 5.84 (13.94) 6.35 (14.58) 6.07 (14.25) 5.94 (14.10) | 5.86 (14.00) 5.30 (13.30) 4.42 (12.13) |
| T₉        | Control                          |         | 6.38 (14.62) 6.53 (14.80) 6.68 (14.97) 6.81 (15.12) | 7.61 (16.00) 7.88 (16.29) 8.14 (16.57) |
|           | SEM(±)                           |         | 0.31 (0.32) 0.31 (0.31) 0.44 (0.47) 0.48 (0.47) | 0.30 (1.42) 1.47 (1.47) 0.91 |
|           | CD at 5%                          |         | N/A 0.92 (0.94) 1.36 (0.30) 1.42 (0.30) | 1.47 (0.30) |

Figures in parentheses are angular transformed values.

DBS = Day before spray

DAS = Days after spray

Table 3: Yield and economics of different treatments
| Treatment No. | Treatments name | Dose/ha   | Yield of grains (q/ha) | Increase in yield over control (q/ha) | Value of increased Yield (Rs./ha) | Additional Cost of treatments (Rs./ha) | Additional Net profit (Rs./ha) | Cost benefit ratio |
|--------------|----------------|-----------|------------------------|---------------------------------------|-----------------------------------|---------------------------------------|---------------------------------|------------------|
| T₁           | Imidacloprid 17.8 SC | 200 ml/ha | 37.26                  | 10.66                                 | 31,980                           | 3,620                                 | 28,360                          | 1:7.83           |
| T₂           | Thiamethoxam 25 WG | 100 gm/ha | 36.05                  | 9.45                                  | 28,350                           | 3,300                                 | 25,050                          | 1:7.59           |
| T₃           | Fipronil 5 SC     | 1000 ml/ha| 38.35                  | 11.75                                 | 35,250                           | 4,600                                 | 30,650                          | 1:6.66           |
| T₄           | Lambda cyhalothrin 5 EC | 500 ml/ha | 33.12                  | 6.52                                  | 19,560                           | 3,625                                 | 15,935                          | 1:4.39           |
| T₅           | Cartap hydrochloride 4 G | 750 gm/ha | 33.87                  | 7.27                                  | 21,810                           | 3,310                                 | 18,500                          | 1:5.59           |
| T₆           | *Beauveria bassiana* 2 x 10⁹ c.f.u./gm | 2.5 kg/ha | 36.03                  | 9.43                                  | 28,290                           | 5,000                                 | 23,290                          | 1:4.65           |
| T₇           | *Metarhizium anisopliae* 4.7 x 10⁸ c.f.u./gm | 2.5 kg/ha | 34.65                  | 8.05                                  | 24,150                           | 5,000                                 | 19,150                          | 1:3.83           |
| T₈           | *Verticellium lacani* 2 x 10⁸ c.f.u./ml | 2.5 lt./ha | 32.51                  | 5.91                                  | 17,730                           | 5,000                                 | 12,730                          | 1:2.55           |
| T₉           | Control          | -         | 26.60                  | -                                     | -                                 | -                                    | -                               | -                |

Labour charge @ Rs. 450.0/day.

Sale price of product @ Rs. 3,000/q.

Charges of sprayer @ Rs. 50/day