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Efficacy of different insecticides against brown planthopper, *Nilaparvata lugens* (Stål) in rice

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Abstract
The on farm trials were conducted to determine the efficacy of conventional and novel insecticides against brown planthopper (BPH), *Nilaparvata lugens* (Stål), in rice during *kharif* 2017 and 2018. All the treatments were effective for BPH management than control. The results of the first year study revealed that the application of Imidacloprid 17.8 SL @ 100 ml ha^{-1} was found superior by registering lower population of BPH (4.70/ hill) followed by Flonicamid 50 WG @ 150 g ha^{-1} with 5.67 BPH/hill after 7 days after spray. However, during the second year trial conducted on different insecticides revealed that BPH population was recorded lowest *i.e.,* 3.60 per hill with the application of Buprofezin 25 SC @ 1000 ml ha^{-1} after 10 days after spray. The effect of this insecticide application was also resulted in the highest grain yield (74.51 q/ha) and maximum benefit cost ratio (6.09).

Keywords: Brown planthopper, insecticide, rice, benefit-cost ratio, grain yield

Introduction

Rice (*Oryza sativa* L.*)* is one of the world's most important food crops for 4.0 billion people (Kulagod *et al*., 2011) [13]. It is the staple food for nearly 2.7 billion Asian people who consume about 90 per cent of world's rice (Zainab and Singh, 2016) [27]. It is also a staple food crop for more than two third of the population in India. As, high yielding varieties of rice produce plenty of calories to the Indian Population (Matharu and Tanwar, 2018) [18]. India is the largest rice growing country across the world having 43 million hectare area under this crop with production of 115 million tons of milled rice and average productivity of 2.7 tons per hectare. Major rice growing states of India are West Bengal, Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh, Bihar, Chhattisgarh, Odisha, Assam and Haryana. Amongst all, Punjab is known as rice bowl of India. With only 1.54 per cent of total geographical area of the country, Punjab has become the major rice contributor to the central pool of food grains with a 3.0 million hectare total cultivated area under this crop. The annual grain production and productivity of rice have been recorded as 19.9 million tons and 6.5 tons per hectare, respectively (Anonymous, 2019) [2].

The average per hectare productivity in the country is relatively low as compared to other Asian countries due to heavy losses caused by biotic factors such as insect-pests (Dhawan *et al*., 2011) [4]. Nearly 300 species of insects are known as pest of this crop, out of which 23 species are of major economic significance (Pasalu and Katti, 2006) [19]. Among them, brown planthopper (BPH), *Nilaparvata lugens* (Stål) is the most notorious pest of rice (Seni and Naik, 2017) [21]. Almost 60 per cent yield loss has been reported under epidemic conditions due to this devastating pest (Kumar *et al*., 2012) [14]. The estimated loss caused by BPH in Asia is more than 300 million dollar annually (Alam and Das, 2017) [1]. Both the nymph and adult stages of this pest cause the direct damage to the crop. The pest sucks the sap from the phloem and xylem which leads to yellowing, wilting, drying up and ultimately the death of the rice plant. Under sever conditions, the damage spreads in a circular fashion which is termed as "hopper-burn". It also causes indirect damage by transmitting viral diseases such as grassy stunt (Chaudhary *et al*., 2014; Ling *et al*., 1978) [3, 16] and reduction of protein content in the leaves (Sarao *et al*., 2016; Vanitha *et al*., 2011) [20, 25].

Although, many insecticides were recommended for the control of this pest, but owing to its feeding behavior at the base of the plant, the farmers were unable to control this pest effectively.

Moreover, many conventional insecticides have been failed to provide adequate control of this pest. Therefore, the present study was planned to find the efficacy of certain new insecticides against BPH in rice.

Materials and Methods

The on farm trials were conducted during the *kharif* 2017 and 2018 at farmer's field of Barnala district in Punjab. The Barnala district is a part of Indo-Gangetic plain and it is situated at 237 meter above the mean sea level. The climate of the district is sub-tropical and the annual average rainfall is recorded as 534 mm, most of which is received during the period of June to September. The soil of the majority of farmer's field is sandy loam and has alkaline pH.

For conducting trials, the recommended variety of rice PR 121 was cultivated with approved package of practice of *Kharif* crops without any plant protection measures. The insecticide treatments include: Imidacloprid 17.8 SL (100 ml ha^{-1}), Flonicamid 50 WG (150 g ha^{-1}), Monocrotophos 36 SL (1000 ml ha^{-1}), Chlorpyrifos 20 EC (2500 ml ha^{-1}), Buprofezin 25 SC (1000 ml ha^{-1}) and Thiamethoxam 25 WG (125 g ha^{-1}) along with control (untreated). The population of brown planthopper was monitored at regular intervals and when it reached the economic threshold level (ETL of 5 BPH/hill) then control measures were initiated to avoid economic losses. All these insecticides were applied with knapsack sprayer. The BPH population (adult and nymphs) were recorded in two phases *i.e.,* day before spray (DBS) and 1st, 5th, 7th and 10th days after spray (DAS). The observations were recorded at randomly selected 10 hills in each treatment field and there were three replications in each treatment. The total count of BPH population was averaged and expressed in per hill basis. The data thus obtained from field experiments were analyzed statistically by ANOVA at 5 per cent level of significance. The grain yield and benefit-cost ratio of different treatments were also calculated. The per cent increase in yield was calculated by following formula.

$$\text{Increase of yield (\%)} = \frac{\text{Yield in treatment-Yield in control}}{\text{Yield in Control}} \times 100$$

Results and Discussion

The data recorded during the first year revealed that the population of brown planthopper remained uniform throughout the experiment prior to the application of treatments. The observation day before spray (DBS) showed that BPH population varied between 10.67 and 11.50 per hill and there was no significant difference among all the treatments (Table 1). However, after 1 DAS all the treatments showed significant reduction in the population of BPH as compared to control. Amongst all the treatments, Imidacloprid 17.8 SL (100 ml ha^{-1}) was found the most effective for the reduction of BPH population after 1 DAS, followed by Flonicamid 50 WG (150 g ha^{-1}) and Monocrotophos 36 SL (1000 ml ha^{-1}). These treatments showed reduction of BPH population from 10.93 to 8.43, 10.67 to 8.63 and 11.50 to 9.27 per hill after 1 DAS of Imidacloprid 17.8 SL (100 ml ha^{-1}), Flonicamid 50 WG (150 g ha^{-1}) and Monocrotophos 36 SL (1000 ml ha^{-1}), respectively. At 5 DAS, Imidacloprid 17.8 SL (100 ml ha^{-1}) was found effective followed by Monocrotophos 36 SL (1000 ml ha^{-1}) and Flonicamid 50 WG (150 g ha^{-1}). These treatments showed reduction of BPH population to 6.33, 7.07 and 7.33 per hill in Imidacloprid 17.8 SL (100 ml ha^{-1}), Monocrotophos 36 SL (1000 ml ha^{-1}) and Flonicamid 50 WG (150 g ha^{-1}), respectively. The same trend in reduction of BPH population was also observed at 7 DAS as the application of Imidacloprid was found significantly superior to all the treatments for the reduction of BPH population. However, there was a gradual increase in the population of BPH at 10 DAS. But, no significant difference was observed between Imidacloprid 17.8 SL and Flonicamid 50 WG. Monocrotophos 36 SL (1000 ml ha^{-1}) was found the least effective among all treatments. The initial BPH population was observed as 11.50 which reduced to 9.27, 7.07, 5.33 and 6.67 BPH per hills after 1, 5, 7 and 10 DAS, respectively. However, with the application of Imidacloprid 17.8 SL (100 ml ha^{-1}), the initial BPH population such as 10.93 decreased to 8.43, 6.33, 4.70 and 5.10 BPH per hill after 1, 5, 7 and 10 DAS, respectively. The data on yield attributes of all the treatments revealed that the highest yield (77.96 q/ha) was observed with the treatment of Imidacloprid 17.8 SL (100 ml ha^{-1}) followed by Flonicamid 50 WG (150 g ha^{-1}) and Monocrotophos 36 SL (1000 ml ha^{-1}) with the average yield of 76.29 and 75.80 q/ha, respectively (Table 3). Similarly, the maximum increase in yield and benefit cost ratio was recorded with the application of Imidacloprid 17.8 SL (100 ml ha^{-1}) over control i.e., 19.08 percent and 5.93, respectively. The corresponding figures were observed as 16.53 percent and 5.72 with the treatment of Flonicamid 50 WG (150 g ha^{-1}), and 15.78 percent and 5.73 with the application of Monocrotophos 36 SL (1000 ml ha^{-1}), respectively. The results of the present study corroborate with findings of Krishnaiah *et al*., (2004) [12] who have also found the effectiveness of application of Imidacloprid in suppressing the BPH population. Sulagitti *et al.*, (2017) [23] reported that the application of Acetamiprid and Imidacloprid were the most effective against BPH. In earlier studies also, scientists reported the efficacy of Imidacloprid against the BPH and other sucking pest of rice and other cereal crops (Hegde, 2005; Ghosh *et al*., 2009; Firake *et al*., 2010; Matharu and Tanwar, 2019) [8, 6, 5,17].

The data recorded during the second year revealed that population of brown planthopper remained uniform throughout the experiment prior to the application of treatments. The observation day before spray (DBS) showed that BPH population varied between 11.73 and 12.57 per hill and there was no significant difference among all the treatments (Table 2). However, after 1 DAS among all the treatment there was no significant difference for the reduction of BPH population as compared to control except Chlorpyrifos 20 EC (2500 ml ha^{-1}). Amongst all the treatments, Chlorpyrifos 20 EC (2500 ml ha^{-1}) was found the most effective for the reduction of BPH population after 1 DAS, followed by Thiamethoxam 25 WG (125 g ha^{-1}) and Buprofezin 25 SC (1000 ml ha^{-1}). These treatments showed reduction of BPH population from 12.57 to 8.87, 12.33 to 10.73 and 11.73 to 11.13 per hills after 1 DAS, with the application of Chlorpyrifos 20 EC (2500 ml ha^{-1}), Thiamethoxam 25 WG (125 g ha^{-1}) and Buprofezin 25 SC (1000 ml ha^{-1}), respectively. At 5 and 7 DAS, Buprofezin 25 SC (1000 ml ha^{-1}) was found the most effective treatment followed by Chlorpyrifos 20 EC (2500 ml ha^{-1}) and Thiamethoxam 25 WG (125 g ha^{-1}). These treatments showed reduction of BPH population to 4.70, 4.87 and 5.40 per hill with application of Buprofezin 25 SC (1000 ml ha^{-1}), Chlorpyrifos 20 EC (2500 ml ha^{-1}) and Thiamethoxam 25 WG (125 g ha^{-1}) at 5 DAS, respectively. The same trend was observed at 7 DAS with the application of all treatments. At 10 DAS, there was no significant difference between Chlorpyrifos 20 EC (2500 ml ha^{-1}) and Buprofezin 25 SC (1000 ml ha^{-1}). Overall, Thiamethoxam 25 WG (125 g ha^{-1}) was found the least effective among all treatments. As, the initial BPH population was observed as 12.33 which reduced to 10.73, 5.40, 4.63 and 4.80 BPH per hill after 1, 5, 7 and 10 DAS, respectively. However, Buprofezin 25 SC (1000 ml ha^{-1}) was found the most effective among all treatments. The initial BPH population was observed as 11.73 which reduced to 11.13, 4.70, 3.83 and 3.60 BPH per hill after 1, 5, 7 and 10 DAS, respectively. The data on yield attributes of all the treatments revealed that the highest yield (74.51 q/ha) was observed in Buprofezin 25 SC (1000 ml ha^{-1}) followed by Chlorpyrifos 20 EC (2500 ml ha^{-1}) and Thiamethoxam 25 WG (125 g ha^{-1}) with the average yield of 73.84 and 71.93 q/ha, respectively. Similarly, the maximum increase in yield and benefit-cost ratio were recorded with the application of Buprofezin 25 SC (1000 ml ha^{-1}) over control i.e., 16.00 per cent and 6.09, respectively. The corresponding figures were observed as 14.96 percent and 6.02 with the treatment of Chlorpyrifos 20 EC (2500 ml ha^{-1}) and, 11.99 percent and 5.98 with the application of Thiamethoxam 25 WG (125 g ha^{-1}), respectively (Table 3). The results of the present study are in line with the findings of Kharbade *et al*., (2015) [10] who have also found the efficacy of Chlorpyrifos insecticide for the management of BPH. Wang *et al*., (2008) [26] reported that Buprofezin insecticide was considered safe for environment and human beings. As, Buprofezin insecticide kills the pest by inhibiting the chitin formation in insects. The present study has also revealed that Buprofezin insecticide requires minimum 3-5 days for killing the BPH. Our results were found in agreement with the findings of Shashank *et al*., (2012) [22]. They also have indicated that Buprofezin insecticide requires at least 3 days for exhibiting its full potential for the control of this pest. Kumar *et al*., (2017) [15] observed that application of Buprofezin 25 SC @ 500 ml per hectare was found effective in reducing the population of BPH from 10.50 to 5.60 per hill after 10 DAS. Further, several reports in the literature indicated the effectiveness of Buprofezin and Thiamethoxam for management of BPH (Kendappa *et al*., 2005; Hegde and Nidagundi, 2009; Suri *et al*., 2012) [9, 7, 24]. Konchada *et al*., (2017) [11] also recorded the highest grain yield of rice with the application of Buprofezin.

Table 1: Efficacy of different insecticides against brown planthopper, *Nilaparvata lugens* in rice during *Kharif* 2017

Treatment	Dose/ha	Number of BPH/hill					
		1 DBS	1 DAS	5 DAS	7 DAS	10 DAS	Mean
Monocrotophos 36 SL	1000 ml	11.50 (3.54)	9.27 (3.20)	7.07 (2.84)	5.33 (2.52)	6.67 (2.77)	7.97
Imidacloprid 17.8 SL	100 ml	10.93 (3.45)	8.43 (3.07)	6.33 (2.71)	4.70 (2.39)	5.10 (2.47)	7.10
Flonicamid 50 WG	150 g	10.67 (3.42)	8.63 (3.10)	7.33 (2.89)	5.67 (2.58)	4.53 (2.35)	7.37
Control	-	11.27 (3.50)	11.70 (3.56)	13.50 (3.81)	14.03 (3.88)	16.20 (4.15)	13.34
C.D (p=0.05)	-	NS	0.19	0.18	0.17	0.18	-
SE(m)	-	0.07	0.05	0.05	0.05	0.05	-
SE(d)	-	0.10	0.08	0.07	0.07	0.07	-

Mean of three replication; figures in parenthesis are square root transformation; DBS-day before spray; DAS-day after spray; BPH-brown planthopper; NS-No Significant difference

Table 2: Efficacy of different insecticides against brown planthopper, *Nilaparvata lugens* in rice during *Kharif* 2018

Treatment	Dose/ha	Number of BPH/hill					
		1 DBS	1 DAS	5 DAS	7 DAS	10 DAS	Mean
Thiamethoxam 25 WG	125 g	12.33 (3.65)	10.73 (3.42)	5.40 (2.53)	4.63 (2.37)	4.80 (2.41)	7.58
Chlorpyrifos 20 EC	2500 ml	12.57 (3.68)	8.87 (3.14)	4.87 (2.42)	3.97 (2.23)	4.13 (2.27)	6.88
Buprofezin 25 SC	1000 ml	11.73 (3.57)	11.13 (3.48)	4.70 (2.39)	3.83 (2.20)	3.60 (2.15)	7.00
Control	-	11.97 (3.60)	12.30 (3.65)	14.63 (3.95)	15.13 (4.02)	15.73 (4.09)	13.95
C.D. (p=0.05)	-	NS	0.34	0.11	0.16	0.17	
SE (m)	-	0.09	0.10	0.03	0.05	0.05	
SE (d)	-	0.13	0.14	0.05	0.06	0.07	

Mean of three replication; figures in parenthesis are square root transformation; DBS-day before spray; DAS-day after spray; BPH-brown planthopper; NS-No Significant difference

Table 3: Effect of different insecticides on the grain yield and benefit-cost ratio of rice

Treatment	Dose/ha	Yield (q/ha)	Increase in yield (%)	B:C ratio
Monocrotophos 36 SL	1000 ml	75.80	15.78	5.73
Imidacloprid 17.8 SL	100 ml	77.96	19.08	5.93
Flonicamid 50 WG	150 g	76.29	16.53	5.72
Control	-	65.47	-	-
Thiamethoxam 25 WG	125 g	71.93	11.99	5.98
Chlorpyrifos 20 EC	2500 ml	73.84	14.96	6.02
Buprofezin 25 SC	1000 ml	74.51	16.00	6.09
Control	-	64.23	-	-

B: C ratio- Benefit cost ratio

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