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COMPARING THE EFFECTIVENESS OF VARIOUS INSECTICIDES ON BROWN PLANT HOPPER (*NILAPARVATA LUGENS*) AND ANALYZING THEIR ECONOMIC IMPACT

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ABSTRACT

The field experiment was conducted at the Research field, Hirapuri Colony, IANS, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur, Uttar Pradesh in the season of *Kharif* 2023-2024 to evaluate the bio-efficacy of different insecticides against brown plant hopper (*Nilaparvata lugens*) on paddy crop. The Swarna variety was grown for the experiment using the RBD experimental design. Various insecticides, such as T1 Imidacloprid 17.8 SL, T2 Acetamiprid 20% SP, T3 *Metarhizium anisopliae* 4.7×108 C.F.U./g, and T4 Thiamethoxam 25%WG, were evaluated against BPH. T5 NSKE 5% and T6 Neem oil 2% were also included in the evaluation. The experiment result revealed that imidacloprid 17.8 SL (5.95 BPH/ 10 hills) was found to most effective treatment against the brown plant hopper and significantly decreasing population of hopper followed by thiamethoxam 25%WG (6.32 BPH/ 10 hills), acetamiprid 20% SP (6.51 BPH/ 10 hills), *M. anisopliae* 4.7×108 C.F.U./g (6.96 BPH/ 10 hills), and neem oil 2% (7.49 BPH/ 10 hills). The least effective treatment found was the NSKE 5% (7.84 BPH/ 10 hills). All the treatments significantly reduced the population of brown plant hoppers compared to the control (14.58 BPH/ 10 hills). The plot treated with imidacloprid 17.8 SL had the highest paddy grain yield at 66.34 q/ha, followed by thiamethoxam 25%WG at 55.86 q/ha. The plot treated with imidacloprid 17.8 SL also showed the highest percentage increase in yield over the control at 68.70%. The highest ICBR was observed from the imidacloprid 17.8 SL (1:3.46) and the lowest ICBR was recorded in NSKE 5% (1:1.02) it may be due to its market price and effectiveness of insecticides.
Keywords **:** Bio efficacy, *Nilaparvata lugens,* Population, Insecticides, Treatment

Introduction

Rice (*Oryza sativa* Linn.) is the second most produced cereal in the world and a member of the Poaceae family (Seck *et al.,* 2012). There are 22 natural and two domesticated species. Over half of the world's population relies on rice as a staple diet, making it the most important food crop globally. More than 65% of India's population grows and consumes rice, making it one of the main cereal crops. Rice is essential for providing food security and a sustainable way of life for people. In India, 1294.71 million metric tons of rice is produced over an area of million hectares dedicated to rice cultivation. The most common food consumed by the people of Uttar Pradesh is rice, which makes up 544.17 lakh tons of the total cultivated land that is farmed there (Anonymous, 2023).

Rice is a great nutritional source. Uncooked rice has a substantial quantity of all eight vitamins, including thiamine, riboflavin, and niacin, as well as 77–84 per cent carbs and 6-9% protein, essential amino acids. Rice is usually cultivated by transplanting on puddled soils because it offers more favourable growing conditions for an improved yield. But in order to feed the country's expanding population, rice output will need to increase by about 3% a year over the next 10 years (Kumar *et al*., 2020).

All of the world's temperate, tropical, and subtropical countries cultivate it. Rice comes in two varieties: aromatic and nonaromatic. Aromatic rice makes up a very minor portion of the rice crop. Apart from India, other countries that cultivate rice include Bangladesh, Myanmar, Indonesia, Vietnam, Pakistan, Iraq, Iran, and Afghanistan. The main producing states of basmati rice in India are Western U.P., Uttarakhand, Punjab, and Haryana. The scent and very fine kernels are the most notable features of Basmati rice. When basmati is harvested, stored, ground, cooked, and consumed, it releases a unique aroma (Bharti *et al*., 2018).

There are several reasons for the decline in rice output, such as disease and insect infestation. The main reasons for rice's low production are weeds, diseases, and insect pests. The brown plant hopper, the white-backed plant hopper, the yellow stem borer, and a few other insect pests are among the about 20 insect species that have been classified as serious pests. According to reports, most insect species prey on rice fields (Singh and Dhaliwal, 1996).

The Stem borer, BPH, gall midge, leaf folder, and other pests are responsible for 25%, 15%, 20%, and 30% of the average yield decline in rice, respectively. A variety of insect pests that affect rice have resulted in losses of 15,120 million rupees, or 18.60 per cent of the overall losses (Chandramani *et al.,* 2010). The BPH, *Nilaparvata lugens* is one of the most economic pests of rice.

The Brown plant hopper is a monophagous pest, a tiny insect with a body length of 2.0 to 3.5 mm. This is an insect with a brownish appearance that feeds on plant phloem. Both adults and nymphs harm the rice plant's phloem. The brown plant hopper belongs to the order Hemiptera, suborder Homoptera (Tamrakar, 2010). The brown plant hoppers damage plant directly by sucking plant sap and indirectly by transmitting viral diseases like grassy and ragged stunt. The brown plant hopper caused economic damage by sucking sap from phloem which in turn led to "hopper burn" and several yield losses (Kumar *et al.,* 2022). As a result of nymphs and adults eating at the base of the tillers, plants quickly dry out and turn yellow. Early infestation is characterized by rounded, yellow spots that quickly turn brownish as a result of the plants drying up (Ling, 1975). About 50% of Indian rice farmers use insecticides against various insect pests *viz.,* Stem borer, BPH, WBPH, and Leaf folder (Lakshmi *et al.,* 2010). Controlling insect pests and reducing yield losses through various methods. The use of insecticides is most effective method nowadays which is mainly used by the Indian farmer (Singh, 2000).

Material and Methods

The field experiment has been carried out at Hirapuri colony research field of Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur. The experimental sites have good climate conditions. The minimum temperature during the winter season varies from 15 $^{\circ}$C in eastern parts to 25 $^{\circ}$C in northern parts of the state. The maximum temperature during the hot season varies from 32 $^{\circ}$C in the northern part to 46 $^{\circ}$C in the south western part of eastern the state. Annual relative humidity ranges from 60 to 70% in northern areas (Tarai region) to 30 -40 % in south western part areas. The normal annual rainfall of the is 947.4 mm and also have alluvial and clay soil with good fertility. The research field has a good drainage. All the cultural practices were adopted. For the experiment variety Swarna had been used with spacing of 10cm x 7cm. The crop was cultivated in a plot measuring 3 x 4 m, and rice transplanting took place on 25/07/2023. A randomized block design (RBD) was utilized, involving 7 treatments (including control) with 3 replications for each treatment. Seven treatments T_1 Imidacloprid 17.8 SL, T_2 Acetamiprid 20% SP, T_3 *Metarhizium anisopliae* 4.7×10^8 C.F.U./g, T_4 Thiamethoxam 25%WG, T_5 NSKE 5%, T_6 Neem oil 2%, T_7 Control. Spray was done two times with the help of Knapsack sprayer. First spray of insecticides was done when the population reached at ETL. The observations were recorded on the number of BPH (nymph and adults) present at the base of the rice plants on selected per 10 hills randomly for each plot and tagged. The population of hoppers was recorded one day before spray and 5, 10, and 15 days after spray. The data were transformed and analyzed statistically with help of OPSAT and Microsoft excel.

The yield data in each treatment was recorded separately and subjected to statistical analysis to test the significance of mean yield variation in different treatments. The percent increase in yield over control in various treatments was calculated by using the following formula.

The yield was then translated to a hectare basis. The following formula, provided by Khosla (1977), was used to compute the percentage increase in yield over control. The yield was observed in Kg/ha.

$$\begin{array}{l}\text{Percentage increase of}\\ \text{yield in over control}\end{array} = \frac{\text{(Yield in treatment} - \text{Yield in control)}}{\text{(Yield in control)}} \times 100$$

$$\text{B : C ratio} = \frac{\text{Net benefit over control}}{\text{Total cost of protection}}$$

Result and Discussion

Seven treatments evaluated for their efficacy against brown plant hopper *viz.,* T_1 Imidacloprid 17.8 SL, T_2 Acetamiprid 20% SP, T_3 *Metarhizium anisopliae* 4.7×10^8 C.F.U./g, T_4 Thiamethoxam 25%WG, T_5 NSKE 5%, T_6 Neem oil 2%, T_7 Control. The average survival population of BPH (no. of insects/ 10 hills) was recorded at 5 DAS, 10 DAS, and 15 DAS after each spray. There are two sprays taken for the control of the brown plant hopper population. The first application of the treatments against BPH was when initial population was observed and cross the ETL level and the second application was done after 15 days of first spray.

Bio-Efficacy of various insecticides after first spray

One day before spraying, the pre-treatment observations showed a BPH population ranging from 11.63 to 12.21 hopper/10 hills in different treatments including the control treatment which was statistically non-significant (Table 1). The first application of different treatments after the fifth day. All treatments were prominently better than the control (T0) (12.14 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (5.54 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (6.08 BPH/ 10hills), (T2) acetamiprid (6.13 BPH/ 10 hills), (T3) *M. anisopliae* (6.81 BPH/ 10 hills), (T6) Neem oil (7.72 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (8.18 BPH/ 10 hills). After the tenth day of the first spray of all treatments were prominently better than the control (T0) (12.45 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (5.70 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (6.26 BPH/ 10hills), (T2) acetamiprid (6.61 BPH/ 10 hills), (T3) *M. anisopliae* (7.11 BPH/ 10 hills), (T6) Neem oil (7.85 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (8.35 BPH/ 10 hills). All the treatments are significantly reducing as compared to (T0) control (12.45hoppers/ 10 hills). After fifteenth day of 1st spray all treatments were prominently better than the control (T0) (12.52 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (5.80 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (6.30 BPH/ 10hills), (T2) acetamiprid (6.68 BPH/ 10 hills), (T3) *M. anisopliae* (7.17 BPH/ 10 hills), (T6) Neem oil (7.97 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (8.42 BPH/ 10 hills). All the treatments are significantly reducing as compared to (T0) control (12.52 hoppers/ 10 hills) (Tabel 1 & Fig. 1).

The result of the mean efficacy of the first spray of the various treatments (Table 1 & Fig. 3) revealed (Tabel 1) that the (T1) imidacloprid (5.68 BPH/ 10 hills) was found most effective treatment against brown plant hopper as compared to followed by (T4) Thiamethoxam (6.21 BPH/ 10hills), (T2) acetamiprid (6.47 BPH/ 10 hills), (T3) *M. anisopliae* (7.03 BPH/ 10 hills), (T6) Neem oil (7.85 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (8.32 BPH/ 10 hills). All the treatments significantly reduced the population of hoppers compared to (T0) Control (12.37 BPH/ 10 hills).

Bio-Efficacy of various insecticides after second spray

Table 1 shows the results of the first application of different treatments after the fifth day. All treatments were prominently better than the control (T0) 15.10 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (7.21 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (7.64 BPH/ 10hills), (T2) acetamiprid (7.76 BPH/ 10 hills), (T3) *M. anisopliae* (7.97 BPH/ 10 hills), (T6) Neem oil (8.22 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (8.55 BPH/ 10 hills). After tenth day of second spray all treatments were prominently better than the control (T0) (16.20 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (6.13 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (6.32 BPH/ 10hills), (T2) acetamiprid (6.38 BPH/ 10 hills), (T3) *M. anisopliae* (6.81 BPH/ 10 hills), (T6) Neem oil (7.00 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (7.22 BPH/ 10 hills). The data of the mean population of hoppers was recorded on the fifteenth day after the first spray all treatments were prominently better than the control (T0) (19.09 BPH/ 10 hills). Among all the six treatments, (T1) imidacloprid (5.31 BPH/ 10 hills) was found to be the most effective treatment as compared to followed by (T4) Thiamethoxam (5.37 BPH/ 10hills), (T2) acetamiprid (5.53 BPH/ 10 hills), (T3) *M. anisopliae* (5.93 BPH/ 10 hills), (T6) Neem oil (6.19 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (6.36 BPH/ 10 hills) (Fig. 2).

The result of the mean efficacy of the second spray of the various treatments (Table 1 & Fig. 3) revealed that the (T1) imidacloprid (6.22 BPH/ 10 hills) was found most effective treatment against brown plant hopper as compared to followed by (T4) Thiamethoxam (6.44 BPH/ 10hills), (T2) acetamiprid (6.56 BPH/ 10 hills), (T3) *M. anisopliae* (6.90 BPH/ 10 hills), (T6) Neem oil (7.13 BPH/ 10 hills), and least effective treatment was found (T5) NSKE (7.37 BPH/ 10 hills). All the treatments significantly reduced the population of hoppers compared to (T0) Control (16.80 BPH/ 10 hills).

The overall mean of both sprays

During the investigation of the bio-efficacy of the different treatments (Table 1 & Fig. 3), the result of the mean efficacy of both sprays revealed that (T1) imidacloprid (5.95 BPH/ 10 hills) was found to most effective treatment against the brown plant hopper and significantly decreasing population of hopper followed by (T4) thiamethoxam (6.32 BPH/ 10 hills), (T2) acetamiprid (6.51 BPH/ 10 hills), (T3) *M. anisopliae* (6.96 BPH/ 10 hills), and (T6) neem oil (7.49 BPH/ 10 hills). The least effective treatment found was the (T5) NSKE (7.84 BPH/ 10 hills). All the treatments significantly reduced the population of brown plant hoppers compared to the (T0) control (14.58 BPH/ 10 hills).

The current findings were similar to Dhurwey and Deole, (2021) reported that most effective insecticides found to be imidacloprid followed by thiamethoxam against Brown plant hopper. Kumar (2019) reported that the imidacloprid was most effective insecticides against BPH followed thiamethoxam, *Metarhizium anisopliae*. Das *et al.,* (2019) also reported that imidacloprid was most effective against BPH as compare to other treatments. Ratnakar *et al.,* (2019) also reported that imidacloprid was found most effective treatment against BPH followed by thiamethoxam. Prashant *et al.,* (2015) reported that imidacloprid and thiamethoxam was most effective treatment against BPH as compare to other treatments

Table 1: Bio-efficacy of different insecticides against BPH after the first and second spray.

Treatment	Treatment Name	Dose	Brown plant hopper (No. of insects/ 10 hills)									
			Pre-treatment	After first spray				After second spray				Overall mean of both spray
				5 DAS	10 DAS	15 DAS	Mean of 1st Spray	5 DAS	10 DAS	15 DAS	Mean of 2nd spray	
T1	Imidacloprid 17.8% SL	300g	12.04 (3.96)	5.54 (2.58)	5.70 (2.88)	5.80 (2.90)	5.68 (2.88)	7.21 (3.18)	6.13 (2.26)	5.31 (2.81)	6.22 (2.99)	5.95 (2.93)
T2	Acetamiprid 20% SP	35g	12.10 (3.97)	6.13 (2.97)	6.61 (3.00)	6.68 (3.08)	6.47 (3.04)	7.76 (3.28)	6.38 (3.02)	5.53 (2.85)	6.56 (3.06)	6.51 (3.05)
T3	*Metarhizium anisopliae* 4.7×108 C.F.U./g	2.5 kg	12.21 (3.99)	6.81 (3.10)	7.11 (3.16)	7.17 (3.17)	7.03 (3.15)	7.97 (3.32)	6.81 (2.80)	5.93 (2.93)	6.90 (3.12)	6.96 (3.13)
T4	Thiamethoxam 25% WG	25g	11.84 (3.94)	6.08 (2.96)	6.26 (3.00)	6.30 (3.00)	6.21 (2.99)	7.64 (2.96)	6.32 (3.01)	5.37 (2.81)	6.44 (3.03)	6.32 (3.01)
T5	NSKE 5%	25000 ml	11.85 (3.94)	8.18 (3.36)	8.35 (3.38)	8.42 (3.40)	8.32 (3.38)	8.55 (3.42)	7.22 (3.18)	6.36 (3.02)	7.37 (3.21)	7.84 (3.30)
T6	Neem Oil 2%	5000 ml	11.63 (3.91)	7.72 (3.27)	7.85 (3.30)	7.97 (3.32)	7.85 (3.30)	8.22 (3.36)	7.00 (3.14)	6.19 (2.98)	7.13 (3.17)	7.49 (3.23)
T7	Control (untreated plot)	-	12.03 (3.96)	12.14 (3.98)	12.45 (4.02)	12.52 (4.03)	12.37 (4.01)	15.10 (4.38)	16.20 (4.52)	19.09 (4.86)	16.80 (4.59)	14.58 (4.31)
CD (5%)			NS	0.81	0.81	0.78	-	0.70	0.32	0.84	-	
SEM			0.07	0.85	0.85	0.85	-	1.04	1.37	1.90	-	

Figures in the parentheses are square root of x + 0.5 transformations.

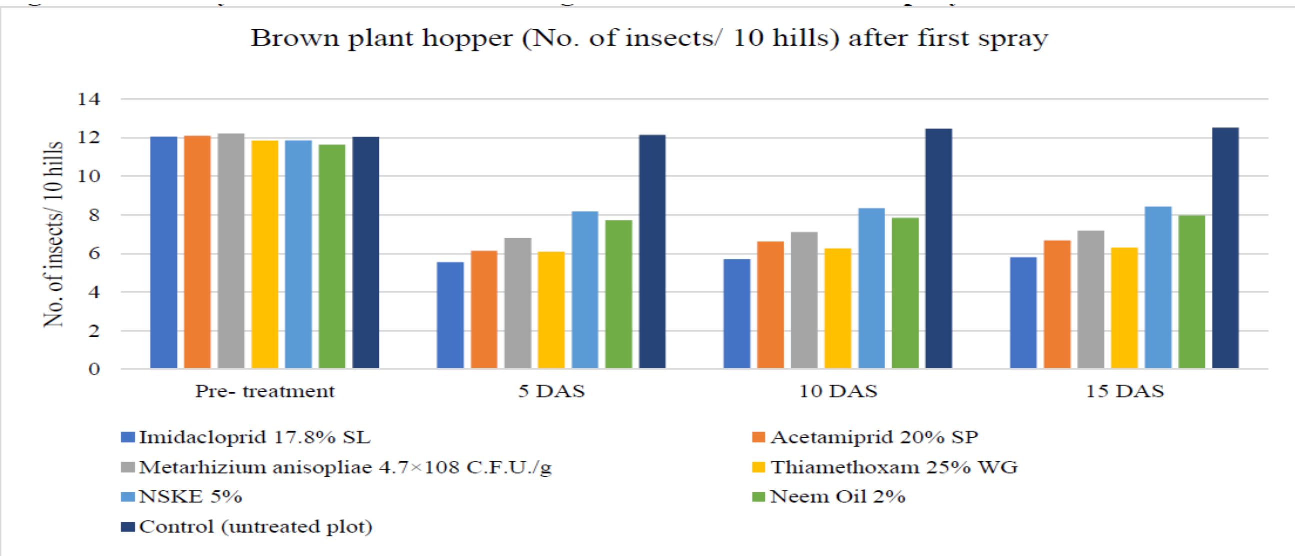

Fig. 1 : Bio-efficacy of different insecticides against BPH after the first spray.

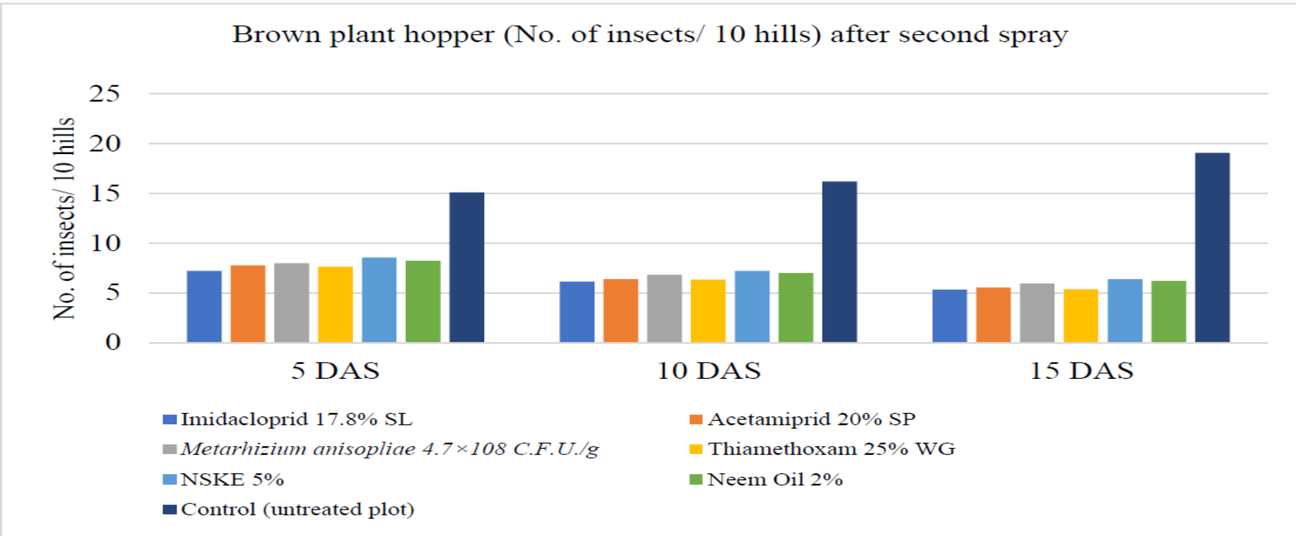

Fig. 2 : Bio-efficacy of different insecticides against BPH after the second spray.

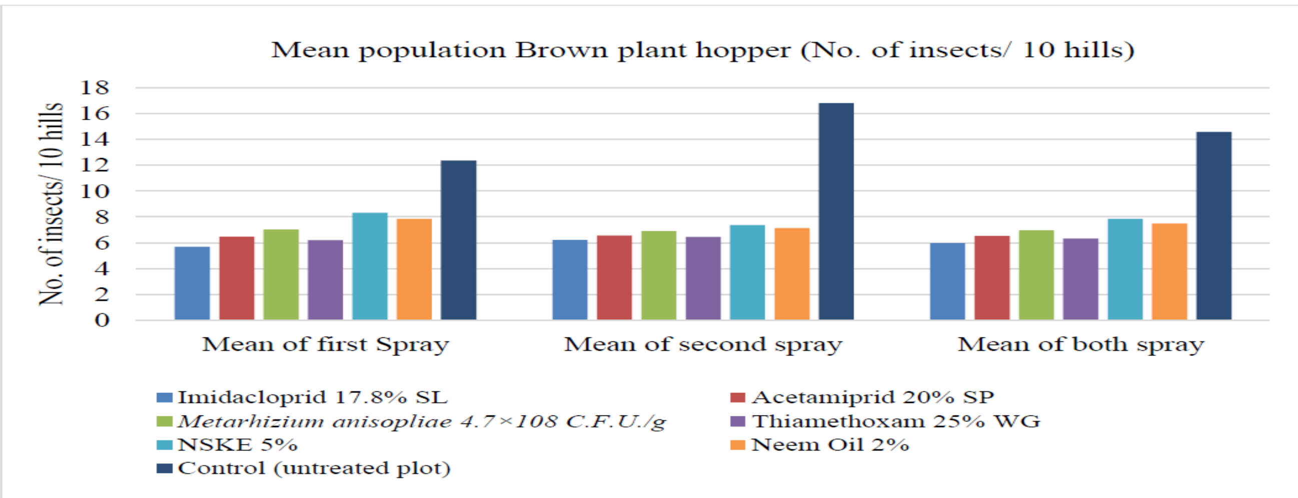

Fig. 3 : Mean observation of BPH population after spraying of treatments.

Calculation of the cost-benefit ratio of the different insecticides

The yield of paddy grains was significantly higher in all the treated plots in compare with the control (untreated plot) (20.76 q/ha). The grain yield of paddy was observed higher in plot treated with (T1) imidacloprid (66.34 q/ha), followed by (T4) Thiamethoxam (55.86 q/ha), (T2) acetamiprid (46.89 q/ha), (T3) *M. anisopliae* (40.25 q/ha), (T6) neem oil (33.52 q/ha), and (T5) NSKE (31.02 q/ha) (Table 2 & Fig. 4). The different insecticides used for the control of brown plant hoppers and after harvesting the crop. The result revealed that the (T1) imidacloprid (68.70%) treated plot has the highest percentage increase in yield over the control followed by (T4) thiamethoxam (62.83%), (T2) acetamiprid (55.72%), (T3) *M. anisopliae* (48.42%), (T6) neem oil (38.06%), and the lowest yield collected from (T5) NSKE (33.07%) compared to the control (Table 2).

The calculation of the cost-benefit ratio was given in Table 2, it was revealed that during *Kharif* season, 2023 that the maximum cost-benefit ratio was recorded in treated plot with (T1) imidacloprid (1:3.46) followed by (T4) thiamethoxam (1:2.82), (T2) acetamiprid (1:2.33), (T3) *M. anisoplae* (1:1.83), (T6) neem oil (1:1.23) and (T5) NSKE (1:1.02).

Table 2 : Economics of the yield

Tr. No.	Treatments name	Dose/ha	Yield (Qt./ha)	Market Price of Paddy (Rs. /qt.)	Total cost of yield (Rs.)	Common output cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	Net Return (Rs.)	B: C Ratio
T1	Imidacloprid 17.8% SL	300g	66.34 (68.70)	2183	144820.20	30200	2208	32408	112412.20	1:3.46
T2	Acetamiprid 20% SP	35g	46.89 (55.72)	2183	102360.90	30200	450	30650	71710.87	1:2.33
T3	*Metarhizium anisopliae* 4.7×10^8 C.F.U	2.5kg	40.25 (48.42)	2183	87865.75	30200	780	30980	56885.75	1:1.83
T4	Thiamethoxam 25% WG	25g	55.86 (62.83)	2183	121942.40	30200	1650	31850	90092.38	1:2.82
T5	NSKE 5%	25000 ml	31.02 (33.07)	2183	67716.66	30200	3250	33450	34266.66	1:1.02
T6	Neem oil 2%	5000 ml	33.52 (38.06)	2183	73174.16	30200	2475	32675	40499.16	1:1.23
T7	Control (Untreated plot)	-	20.76	2183	45319.08	30200	-		-	-

* Figures in the parentheses are percent increase in yield over control.

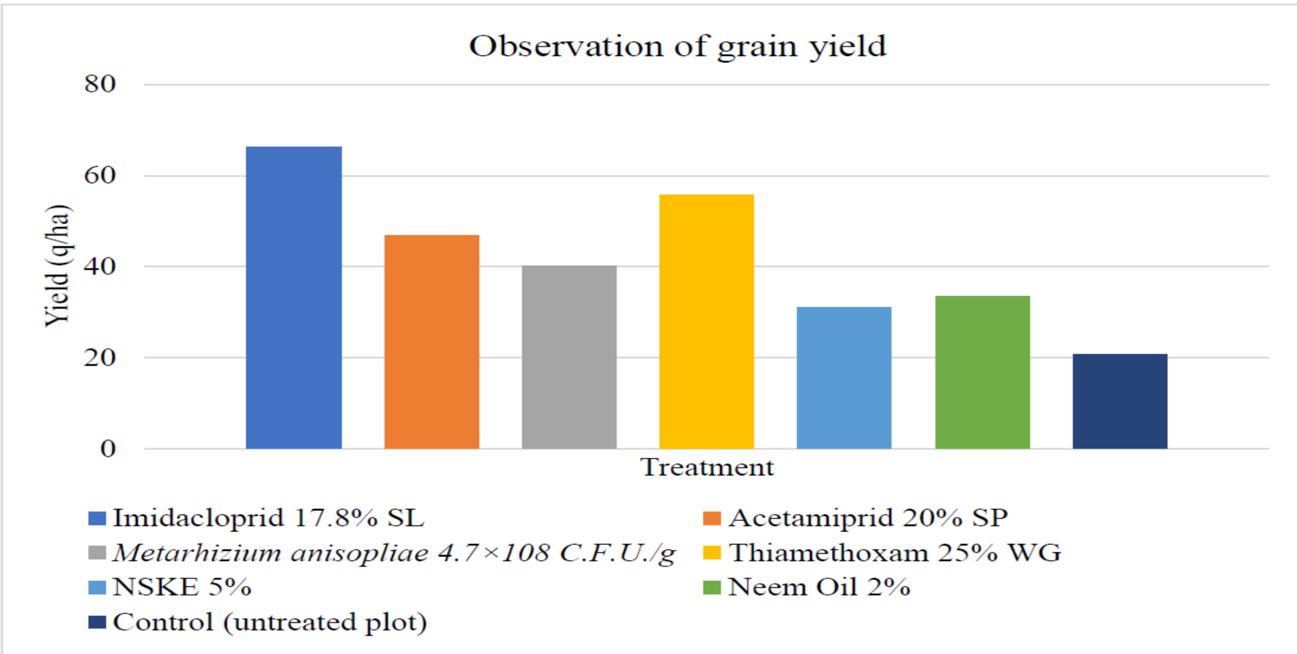

Fig. 4 : Effect of different treatments on paddy production during *Kharif* season 2023

Conclusion

The various treatments *viz.,*imidacloprid, acetamiprid, *M. anisopliae,* thiamethoxam, NSKE, and neem oil were evaluated for their efficacy against brown plant hopper, *Nilaparvata lugens.* Among all the treatments (T1) imidacloprid (5.95 BPH/ hills) was found to be the most effective treatment as compared to other treatments. The second most effective treatment was (T4) thiamethoxam (6.32 BPH/ 10 hills) followed by (T2) acetamiprid (6.51 BPH/ 10 hills), (T3) *M. anisopliae* (6.96 BPH/ 10 hills)*,* and (T6) neem oil (7.49 BPH/ 10 hills), and the found the least effective treatment against hoppers was (T5) NSKE (7.84 BPH/ 10 hills). All treatments significantly reduced the population of BPH as compared to (T0) Control (14.58 BPH/ 10 hills). The result revealed that the (T1) imidacloprid (68.70%) treated plot has the highest percentage increase in yield above the control followed by (T4) thiamethoxam (62.83%) and the lowest yield was observed from (T5) NSKE (33.07%) compared to the control. The highest ICBR was obtained from the (T1) imidacloprid (1:3.46) because of its lower price and effectiveness against brown plant hoppers. The lowest ICBR was record from (T5) NSKE (1:1.02) because of its higher price and low effectiveness against brown plant hoppers.

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