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Efficacy of various insecticides against brown plant hopper, *Nilaparvata lugens* (Stal) in rice, *Oryza sativa* L.

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Abstract
A field experiment was conducted to determine the comparative efficacy of some insecticides against brown plant hoppers (BPH) in rice during *kharif* 2020. The treatments were acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L, fipronil 5 SC @ 2.0 ml/L, flonicamid 50 WG @ 0.30g/, imidacloprid 17.8 SL @ 0.20ml/L, thiamethoxam 25 WG @ 0.20g/L, quinalphos 25EC @ 2.0ml/L and untreated control. Fipronil 5 SC @ 2.0 ml/L found to the most effective treatment for the control of BPH by recording the highest percent reduction of 85.45% over untreated control among all the treatments and it was follwed clothianidin 50 WDG @ 0.05g/L (85.09), thiamethoxam 25 WG @ 0.20g/L (84.53) acephate 75 SP @ 1.50g/L (84.31), imidacloprid 17.8 SL @ 0.20ml/L (84.17) and flonicamid 50 WG @ 0.30g/L (83.21). The untreated control recorded maximum of 36.23, 39.27 and 41.20 number of BPH/hill at 3, 7 and 14 days after second spray. The grain yield differnce due to various insecticidal treatments were significant. The treatment with fipronil 5 SC @ 2.0 ml/L recorded highest yield of 55.43 q/ha. However, it was at par with clothianidin 50 WDG @ 0.05g/L (53.97), imidacloprid 17.8 SL @ 0.20ml/L (53.61), thiamethoxam 25 WG @ 0.20g/L (53.30), flonicamid 50 WG @ 0.30g/L (53.24) and acephate 75 SP @ 1.50g/L (51.42). The lowest of 37.35 q/ha grain yield was recorded in untreated control. The highest 97.40 percent increase in yield over control was recorded in treatment with fipronil 5 SC @ 2.0 ml/L. It was followed by clothianidin 50 WDG @ 0.05g/L (92.20), imidacloprid 17.8 SL @ 0.20ml/L (90.91), thiamethoxam 25 WG @ 0.20g/L (89.81), flonicamid 50 WG @ 0.30g/L (89.60) and acephate 75 SP @ 1.50g/L (83.12).

Keywords: Rice insect pests, brown plant hopper, insecticides, natural enemies, grain yield

Introduction
India is world's second largest rice producer. In India total area under rice 43.79 million hectors with production of 109.70 million tonnes with productivity of 2494 kg/ha (Anonymous, 2018) [1]. However, in Maharashtra state it is cultivated over an area about 14.66 lakh/ha with production about 34.19 lakh tonnes having productivity 1.84 tonnes/ha (Anonymous, 2018) [2]. Major Rice growing districts in Maharashtra are Thane, Ratnagiri, Raigad, Sindhudurg Kolhapur and Nashik.

Rice, *Oryza sativa* a cereal crop, belongs to the family Gramineae. It is staple food for more than half of human population. Rice constitutes 52 percent of total food grain production and 55 percent of total cereal production in India (Sexena and Sing, 2003) [16]. It is one of the world's most important crops providing a staple food for more than half of the global population (Kulagod *et al*., 2011) [12]. It is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. It alone provides 20% of the world's dietary energy supply (FAO, 2004) [8]. But, rice production is hampers by infestation of a large number of insect pests. Nearly 300 species of insect pests attack the rice crop at different stages and among them only 23 species cause notable damage (Pasalu and Katti, 2006) [14]. Brown plant hopper is one of the major culprits for huge economic crop losses of rice. It attacks the crop from late vegetative stage to grains hardening stage. Both the nymphs and adults suck the sap from the plant resulting in chlorotic, wilting and drying up of rice plant. This feeding symptoms of damage is commonly known as 'hopper-burn' which begins in patches but spread rapidly as the hoppers move from dying plants to adjacent plants. Generally the yield losses due to hoppers ranges from 10% to 90% but if timely control measures are not taken up, there may be possibility of total crop loss within a very short period. Beside this direct feeding damage, it also serves as the vector of Rice Grassy Stunt and Ragged Stunt Viruses (Ling, 1977) [13].

Most of the farmers depends on insecticides for their management and almost 50% of the insecticides used in rice are targeted against this pest alone (Reddy *et al*., 2012) [15]. Many conventional insecticides though have been evaluated against this insect, yet, most of the chemicals have failed to provide adequate control. Hence, new insecticides are being evaluated with an aim to least disruption of environmental system. For this purpose, the present study was carried out to find the efficacy of various insecticide against brown plant hoppers in rice.

Materials and Methods

Field experiment was conducted in the experimental farm of Zonal Agriculture Research Station, Igatpuri Dist. Nashik, Maharashtra during *kharif*, 2020 in Randomized Block Design (RBD), having 8 treatments which were replicated thrice in plot size of 3.75 m x 2.95 m i.e. 16 rows of 3.20 m length with 15 x 25 cm spacing. Nursery of rice variety Indrayani sown in the second week of June in *kharif*, 2020 and transplanting was done after 30 days of sowing at 15×25 cm^2 hill spacing. All the agronomic practices were followed during crop growth period. The treatments were *viz*., acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L, fipronil 5 SC @ 2.0 ml/L (6.93), flonicamid 50 WG @ 0.30g/L (6.70) imidacloprid 17.8 SL @ 0.20ml/L, thiamethoxam 25 WG @ 0.20g/L, quinalphos 25EC @ 2ml/L and untreated control. The insecticides were applied as high volume sprays @ 500 lits of spray fluid/ha. Sprayings was given by using a hand compression knapsack high volume sprayer during morning hours. The plot in each treatment was sprayed with respective insecticides ensuring uniform coverage of insecticide. The treatments imposed when the pest reached ETL. The data were recorded on population of BPH on 10 randomly selected hills from each plot at one day before the application of treatments as a pre count and post count at three, seven and fourteen days after spray. The percent population reduction of brown plant hopper at each count were calculated. Finally the grain yield was recorded on plot basis and expressed in quintal/ha. The data obtained for field experiments were subjected to statistical analysis.

Results and Discussion

Data pertaining to effect of various insecticides on brown plant hopper control in rice is depicted in Table 1 to 3. The data indicated significant differences among the treatments at 3, 7 and 14 days after first and second spray. There were no significant differences among the treatments before the application of first spray. The data indicated that the treatments fipronil 5 SC @ 2.0ml/L proved to be significantly effective against control of BPH which recorded minimum number of 8.80 number of BPH/hill at 3 days after first spray. It was at par with clothianidin 50 WDG @ 0.05g/L (9.60), thiamethoxam 25 WG @ 0.20g/L (9.73), imidacloprid 17.8 SL @ 0.20ml/L (10.03) and acephate 75 SP @ 1.50g/L (10.43). At 7 days after spray, the population of BPH were not recorded in treatment with acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L and fipronil 5SC @ 2.0 ml/L i.e. cent percent control of BPH was observed. At 14 DAS, flonicamid 50 WG @ 0.30g/L recorded signifcantly minimum 0f 7.07 number of BPH/hill. It was at par with thiamethoxam 25 WG @ 0.20g/L (8.40), acephate 75 SP @ 1.50g/L (8.47), fipronil 5 SC @ 2.0ml/L (8.63) and clothianidin 50 WDG @ 0.05g/L (8.73). The untreated control recorded significantly maximum number of 20.27, 26.10 and 31.40 number of BPH hill at 3, 7 and 14 days after first spray. The data regarding the efficacy of treatments after first spray revealed that fipronil 5 SC @ 2.0ml/L proved to be the most effective treatment by recording the highest percent population reduction of 76.37 over untreated control after first spray. It was followed by clothianidin 50 WDG @ 0.05g/L (74.94), thiamethoxam 25 WG @ 0.20g/L (74.44) and acephate 75 SP @ 1.50g/L (73.86).

The data presented in Table 2 revealed that the significant differences among the treatments were recorded at 3, 7 and 14 days after second spray. At 3 days after second spray the significantly minimum of 4.10 number of BPH were recorded in treatment clothianidin 50 WDG @ 0.05g/L and it was at par with acephate 75 SP @ 1.50g/L (4.53), imidacloprid 17.8 SL @ 0.20ml/L (4.60), fipronil 5 SC @ 2.0 ml/L (4.70) and thiamethoxam 25 WG @ 0.20g/L (4.83). At 7 days after spray the treatments with acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L, imidacloprid 17.8 SL @ 0.20ml/L and thiamethoxam 25 WG @ 0.20g/L were not recorded the population of BPH i.e. plot sprayed with these treatments were free from infestation of BPH. At 14 days after second spray, the treatment with imidacloprid 17.8 SL @ 0.20ml/L recorded minimum of 0.63 number of BPH/hill and it was at par fipronil 5 SC @ 2.0 ml/L (0.80). The data regarding the overall percent population reduction over control, the imidacloprid 17.8 SL @ 0.20ml/L found tobe the most effective treatment for the control of BPH by recording the highest percent reduction of 95.26% over control among all the treatments. The untreated control recorded maximum of 36.23, 39.27 and 41.20 number of BPH/hill at 3, 7 and 14 days after second spray.

Data from Table 3 revealed that the treatment with fipronil 5 SC @ 2.0 ml/L recorded highest of 85.45 percent reduction of BPH over control at combinatted of first and second spray and it was follwed by clothianidin 50 WDG @ 0.05g/L (85.09), thiamethoxam 25 WG @ 0.20g/L (84.53), acephate 75 SP @ 1.50g/L (84.31) and imidacloprid 17.8 SL @ 0.20ml/L (84.17).

The data presented in Table 3 revealed that the grain yield differnce due to various insecticidal treatments were significant. The treatment with fipronil 5 SC @ 2.0 ml/L recorded highest yield of 55.43 q/ha. However, it was at par with clothianidin 50 WDG @ 0.05g/L (53.97), imidacloprid 17.8 SL @ 0.20ml/L (53.61), thiamethoxam 25 WG @ 0.20g/L (53.30), flonicamid 50 WG @ 0.30g/L (53.24) and acephate 75 SP @ 1.50g/L (51.42). The lowest of 37.35 q/ha grain yield was recorded in untreated control. The highest 97.40 percent increase in yield over control was recorded in treatment with fipronil 5 SC @ 2.0 ml/L. It was followed by clothianidin 50 WDG @ 0.05g/L (92.20), imidacloprid 17.8 SL @ 0.20ml/L (90.91), thiamethoxam 25 WG @ 0.20g/L (89.81), flonicamid 50 WG @ 0.30g/L (89.60) and acephate 75 SP @ 1.50g/L (83.12). The data presented in Table 3 revealed that the population differnce of natural enemies due to various insecticidal treatments were significant.the untreated control recorded the highest of 2.33 and 3.33 number of natural enemies/m^2 after first and second spray.The treatment with quinalphos 25EC @ 2ml/L wsa not recorded any number of natural enemies. It indicated the harmful effect of spraying of quinalphos 25EC.

In the present findings the insecticides *viz.* flonicamid 50 WG @ 0.30g/L, acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L, imidacloprid 17.8 SL @ 0.20ml/L and fipronil 5 SC @ 2.0 ml/L were found effective for controlling the

population of brown plant hopper in *kharif* rice and recorded highest grain yield over control.This results are in close conformity of results reported by Patil *et al*., 2020 [18]. All the insecticidal treatments were superior in brown plant hopper management and differ significantly for untreated control. Different scientist were reported the effectiveness of thiamethoxam 25 WG for management of BPH (Kendappa *et al*., 2005, Hegde and Nidagundi, 2009 and Suri *et al*., 2012) [9, 10, 16, 17]. The results of present findings are also in corroboration with result of Bhavani and Rao (2005) [4] who reported the higher yield of rice in plots treated with thiamethoxam @ 0.025kg.a.i/ha (4.98 t/ha), acetamiprid @ 0.020kg.a.i/ha (4.52 t/ha) and clothianidin @ 0.015 kg.a.i/ha (4.48 t/ha). Deekshita *et al*., 2017 evaluated various newer insecticide *viz*., imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 SP were found effective for the control of BPH in rice over untreated control. The results of the present findings are in conformity with those reported by Deekshita *et al*., 2017 [6] and Atana Seni and Bhima Sen Naik, 2017 [3]. Many scientists documented the good efficacy of acephate 75SP against hoppers on rice (Bhavani and Rao, 2005, De-Jin *et al*., 2010, Fabellar and Heinrichs, 2003) [4, 5, 7].

Table 1: Efficacy of different insecticides on population of brown plant hopper (BPH) after first spray and percent population reduction over control

TN	Name of the insecticidal treatments	Dose per liter	Population of brown plant hopper/hill				Percent population reduction over control			Overall reduction (%)
			Pre count	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	
1	Acephate 75 SP	1.50 g	17.60 (4.31)	10.43 (3.38)	0.00 (1.00)	8.47 (3.08)	48.54	100.00	73.03	73.86
2	Clothianidin 50 WDG	0.05 g	18.10 (4.37)	9.60 (3.26)	0.00 (1.00)	8.73 (3.12)	52.63	100.00	72.19	74.94
3	Fipronil 5 SC	2.00 ml	17.83 (4.34)	8.80 (3.13)	0.00 (1.00)	8.63 (3.10)	56.59	100.00	72.52	76.37
4	Flonicamid 50 WG	0.30 g	18.03 (4.36)	11.30 (3.51)	0.73 (1.32)	7.07 (2.84)	44.25	97.20	77.48	72.97
5	Imidacloprid 17.8 SL	0.20 ml	18.40 (4.40)	10.03 (3.32)	0.43 (1.20)	9.30 (3.21)	50.51	98.35	70.38	73.08
6	Thiamethoxam 25 WG	0.20 g	18.80 (4.45)	9.73 (3.28)	0.50 (1.22)	8.40 (3.07)	51.99	98.08	73.24	74.44
7	Quinalphos 25 EC	2.00 ml	18.67 (4.44)	12.80 (3.71)	6.03 (2.65)	12.97 (3.74)	36.85	76.90	58.59	57.45
8	Untreated control	-	18.07 (4.37)	20.27 (4.61)	26.10 (5.21)	31.40 (5.69)	-	-	-	-
	SE ±		0.06	0.12	0.06	0.09	-	-	-	-
	CD at 5%		NS	0.36	0.20	0.28	-	-	-	-

Table 2: Efficacy of different insecticides on population of brown plant hopper (BPH) after second spray and percent population reduction over control

TN	Name of the insecticidal treatments	Dose per liter	Population of brown plant hopper/hill				Percent population reduction over control			Overall reduction (%)
			Pre count	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	
1	Acephate 75 SP	1.50 g	8.47 (3.08)	4.53 (2.35)	0.00 (1.00)	1.33 (1.53)	87.50	100.00	96.77	94.76
2	Clothianidin 50 WDG	0.05 g	8.73 (3.12)	4.10 (2.26)	0.00 (1.00)	1.23 (1.49)	88.68	100.00	97.01	95.23
3	Fipronil 5 SC	2.00 ml	8.63 (3.10)	4.70 (2.39)	0.60 (1.26)	0.80 (1.34)	87.03	98.47	98.06	94.52
4	Flonicamid 50 WG	0.30 g	7.07 (2.84)	5.27 (2.50)	0.87 (1.37)	1.20 (1.48)	85.45	97.78	97.08	93.44
5	Imidacloprid 17.8 SL	0.20 ml	9.30 (3.21)	4.60 (2.37)	0.00 (1.00)	0.63 (1.28)	87.30	100.00	98.47	95.26
6	Thiamethoxam 25 WG	0.20 g	8.40 (3.07)	4.83 (2.41)	0.00 (1.00)	1.17 (1.51)	86.67	100.00	97.16	94.61
7	Quinalphos 25EC	2.00 ml	12.97 (3.74)	9.40 (3.22)	3.50 (2.12)	5.97 (2.64)	74.05	91.09	85.51	83.55
8	Untreated control	-	31.40 (5.69)	36.23 (6.10)	39.27 (6.34)	41.20 (6.50)	-	-	-	-
	SE ±		0.09	0.06	0.04	0.06	-	-	-	-
	CD at 5%		0.28	0.18	0.12	0.19	-	-	-	-

DAS- Days after spray, figures in parentheses indicate V_{n+1} transformed value

Table 3: Cumulative efficacy of different insecticides against brown plant hopper *Nilparvata lugens* (Stal.) and their effect on grain yield and natural enemies

TN	Name of the insecticidal treatments	Dose/ liter	Percent population reduction over control			Grain yield q/ha	Percent increase in yield over control	Natural enemies/m^2	
			First spray	Second spray	Mean			First spray	Second spray
1	Acephate 75 SP	1.50 g	73.86	94.76	84.31	51.42	83.12	0.67 (1.29)	0.67 (1.29)
2	Clothianidin 50 WDG	0.05 g	74.94	95.23	85.09	53.97	92.20	1.00 (1.41)	1.33 (1.53)

3	Fipronil 5 SC	2.00 ml	76.37	94.52	85.45	55.43	97.40	0.67 (1.29)	1.33 (1.53)
4	Flonicamid 50 WG	0.30 g	72.97	93.44	83.21	53.24	89.60	1.33 (1.53)	1.00 (1.41)
5	Imidacloprid 17.8 SL	0.20 ml	73.08	95.26	84.17	53.61	90.91	1.00 (1.41)	1.33 (1.53)
6	Thiamethoxam 25 WG	0.20 g	74.44	94.61	84.53	53.30	89.81	0.67 (1.29)	1.00 (1.41)
7	Quinalphos 25 EC	2.00 ml	57.45	83.55	70.50	40.84	45.44	0.00 (1.00)	0.00 (1.00)
8	Untreated control	-	-	-	-	28.08	-	2.33 (1.82)	3.33 (2.08)
	SE +		-	-	-	1.63	-	0.10	0.12
	CD at 5%		-	-	-	4.92	-	0.31	0.37

DAS- Days after spray

Conclusion

All the tested insecticides are found effective for brown plant hopper management but among these insecticides flonicamid 50 WG @ 0.30g/L, acephate 75 SP @ 1.50g/L, clothianidin 50 WDG @ 0.05g/L, imidacloprid 17.8 SL @ 0.20ml/L and fipronil 5 SC @ 2.0 ml/L can be used for the effective management of brown plant hopper in *kharif* rice.

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