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Impact of resurgence inducing insecticides on natural enemies of rice brown planthopper, *Nilaparvata lugens* (Stal)

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Abstract
Field studies carried out during *kharif* and *rabi* 2016-17 at Regional Agricultural Research Station, Maruteru (A.P.), India to assess the impact of resurgence inducing insecticides on natural enemies of brown planthopper infesting rice. The results revealed the significant reduction in the population of mirid bug and spiders due to toxic nature of insecticides *viz.*, chlorpyriphos, profenophos, cypermethrin, deltamethrin, bifenthrin, lambda cyhalothrin and imidacloprid (higher prey-predator ratio) may lead to resurgence in the population of brown planthopper. Hence, it is advised not to recommend or minimize their usage in rice ecosystem.

Keywords: Rice, brown planthopper, resurgence, natural enemies and insecticides

Introduction

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population and accounts for more than 50 per cent of the daily calorie intake (Khush, 2005) [8]. Insect pests and diseases remain the key biotic stresses limiting rice production significantly. Among the insect pests infesting rice, brown planthopper (BPH), *Nilaparvata lugens* (Stal) is considered as the major yield limiting factor in all rice growing countries both in tropics and temperate regions (Krishnaiah, 2014) [10]. In combating BPH, chemical control continues to play a major role in South east Asian countries (Krishnaiah and Kalode, 1987) [9]. Farmers rely solelyon insecticides for management of planthoppers but their repeated applications often result in problems such as development of resistance, induction of resurgence and residues on farm produce besides environmental concern.

There were number of reports and findings on the resurgence of BPH due to several insecticides belonging to organophosphates and synthetic pyrethroids. In majority of insecticide-induced resurgence, the suppression of natural enemies due to insecticides is considered as an important factor contributing to resurgence in BPH (Reissig *et al*.,1982 [14], Raman and Uthamasamy, 1983 [12], Heinrichs and Mochida, 1984 [3], Chellaiah and Uthamasamy, 1986 [1], Krishnaiah and Kalode, 1987 [9]). Several workers also demonstrated the toxic property of the synthetic pyrethroids to the natural enemies of the brown planthopper earlier. Panda and Nayak (2000) [11] reported that deltamethrin with a higher prey-predator ratio (11.43) was highly toxic to the predators and resulted in an increase in the population of white backed planthoppper. According to Tanaka *et al.* (2000) [15] deltamethrin was the most toxic to the spiders followed by etofenprox, whereas phenthoate, imidacloprid and deltamethrin were toxic to green mirid bug. Jhansilakshmi *et al*. (2010) [6] reported that bifenthrin was more toxic to predatory mirid bugs specific to BPH. Neonicotinoid insecticides like imidacloprid and thiamethoxam have been reported to exert adverse effect on green mirid bug (Jhansilakshmi *et al*. 2001) [7].

Keeping this in view, the present field studies were undertaken during *kharif* and *rabi* 2016-17 at Regional Agricultural Research Station, Maruteru (16.38^0 N, 81.44^0 E, 5m asl) (A.P.), India to assess the impact of resurgence inducing insecticides on natural enemies of brown planthopper.

Materials and Methods

The experiment was laid out in a randomized block design (RBD) with fifteen treatments that comprised insecticides *viz.*, chlorpyriphos 50 EC @ 800 ml/ha, acephate 75 SP @ 750 g/ha, profenophos 50 EC @ 1000 ml/ha, monocrotophos 36 SL @ 800 ml/ha, cartap hydrochloride

50 SP @ 1000 ml/ha, cypermethrin 10 EC @ 500 ml/ha, deltamethrin 2.8 EC @ 500 ml/ha, bifenthrin 10 EC @ 500 ml/ha, lambda cyhalothrin 2.5 EC @ 500 ml/ha, imidacloprid 17.8 SL @ 125 ml/ha, chlorantraniliprole 18.5 SC @ 200 ml/ha, fipronil 5 SC @ 1000 ml/ha, buprofezin 25 SC @ 800 ml/ha, pymetrozine 50 WG @ 300 g/ha including untreated control and replicated twice. Plot size was 20.00 m^2 and a buffer area of 0.50 m width was left around each plot. Highlyp lanthopper susceptible rice varieties, Swarna (MTU 7029) and Prabhat (MTU3626) were used during *kharif* and *rabi*, respectively. One or two seedlings were planted per hill with a spacing of 20 cm x 15 cm during *kharif* and 15 cm x 15 cm in *rabi* with a help of a marked rope. The crop husbandry operations were adopted as recommended in the package of practices of Acharya N. G. Ranga Agricultural University, A.P.

Treatments were given thrice at 45, 60 and 75 days after transplanting (DAT) at recommended rates. A spray fluid of 500 L/ha was used in a battery operated hand sprayer to ensure thorough coverage of the crop canopy. Observations on nymphs and adults of BPH and their natural enemies *viz.*, green mirid bug and spiders were counted directly from twenty randomly selected hills per plot at one day before spray (Pre-treatment count) and at ten days after each spray of insecticides (Post-treatment).

After each spray, the resurgence was estimated for each treatment using formula given by Heinrichs *et al.* (1981) [4] and expressed as ratio.

$$\text{Resurgence ratio} = \frac{\text{Number of insects on treated plants}}{\text{Number of insects on untreated plants}}$$

The prey predator (BPH/MB) ratio was also calculated for each treatment which gave an idea of the relative toxicity of the test insecticides to brown planthopper (BPH) compared to its specific predator, green mirid bug (MB). Lower the value of this ratio, higher is the safety to mirid bug and vice versa.

Data collected on mirid bug and spider population were transformed in to square root transformations before analysing the data using analysis of variance technique (ANOVA) (Gomez and Gomez 1984). The treatment means were compared using least significant difference (LSD) at 5% probability.

Results and Discussion

Effect of insecticides on the resurgence of brown planthopper during *kharif* 2016 On the basis of mean data (Table 1) of three sprays applied at fifteen days interval during *kharif* 2016, bifenthrin (1.84 folds), lambda cyhalothrin (1.82 folds), profenophos (1.78 folds), imidacloprid (1.77 folds), deltamethrin (1.75 folds), cypermethrin (1.75 folds) and chlorpyriphos (1.64 folds) registered resurgence in the descending order during *kharif* 2016. Other treatments were not causing resurgence in BPH as the value of resurgence ratio was less than one (<1).

Effect of insecticides on the population of green mirid bug during *Kharif* 2016.

The population of the green mirid bug recorded in various insecticide treated plots along with BPH/MB ratioare presented in Table 1.There was a significant difference in the value of prey predator (BPH/MB) ratio among different treatments. Lambda cyhalothrin and imidacloprid treated plots registered higher BPH/MB ratio of 8.16 and 8.10, respectively were identified as highly toxic compounds to the mirid bug than to the BPH followed by bifenthrin (7.73), profenophos (6.27), deltamethrin (6.06), cypermethrin (5.80) and chlorpyriphos (5.78) and superior over untreated control (5.51). All the resurgence inducing insecticides have recorded higher BPH/MB ratio. The increase in the value of BPH/MB ratio suggested negative impact of insecticides on natural enemies, which in fact resulted in greater multiplication of the BPH.

More favourable ratio of BPH/MB was observed in the plots treated with acephate (3.62), buprofezin (3.20), cartap hydrochloride (3.96), monocrotophos (3.86), chlorantraniliprole (2.07) and pymetrozine (2.35) and on par with untreated control (3.90) indicating their safety towards predatory mirid bug.

Effect of insecticides on the population of spiders during *kharif* 2016

The population of spiders observed at regular intervals along with BPH are presented in Table 1. The population of spiders ranged from 8.33 to 16.33 per 20 hills at ten days after spray and the variations among the treatments were found significant. Treatments with pymetrozine (15.00 Nos./20 hills), acephate (15.17 Nos./20 hills), chlorantraniliprole (14.67 Nos./20 hills), buprofezin (14.33 Nos./20 hills), cartap hydrochloride (15.00 Nos./20h ills), monocrotophos (15.17 Nos./2 0hills) and fipronil (13.67 Nos./20 hills) had significantly higher population of spiders and were on par with untreated control (16.33 Nos./20 hills), while profenophos (8.50 Nos./20hills), cypermethrin (8.50 Nos./20hills), chlorpyriphos (8.33 Nos./20 hills), lambda cyhalothrin (8.33 Nos./20 hills), bifenthrin (10.17 Nos./20 hills), deltamethrin (7.83 Nos./20 hills) and imidacloprid (8.33 Nos./20hills) treated plots recorded lower population of spiders as compared to untreated control plot (16.33 Nos./20 hills).

Effect of insecticides on the resurgence of brown planthopper during *rabi* 2016-17

Mean data of (Table 2) of three sprays applied at fifteen days interval during *rabi* 2016-17 revealed that maximum resurgence in BPH population was observed in bifenthrin (10.42 folds) followed by lambda cyhalothrin (10.14 folds), deltamethrin (7.08 folds), cypermethrin (4.97 folds), profenophos (3.19 folds) and chlorpyriphos (2.56 folds), while minimum resurgence was observed in imidacloprid (1.72 folds) as per the formula suggested by Heinrichs *et al.* 1981 [4]. Rest of the treatments were effective in managing the BPH population as the value of resurgence ratio was less than one (<1).

Effect of insecticides on the population of green mirid bug during *rabi* 2016-17

The population of the predatory mirid bug recorded in various insecticide treatments along with BPH/MB ratio are presented in Table 2. There was a significant difference in the ratio of BPH/MB among different insecticide treatments. Among the treatments, chlorpyriphos and bifenthrin with higher BPH/MB ratio of 13.52 and 11.76 were identified highly toxic to the mirid bug than to the BPH. It was followed by lambda cyhalothrin, deltamethrin, profenophos, imidacloprid and cypermethrin with BPH/MB ratio of 11.06, 10.34, 8.89, 8.71 and 7.83. All the resurgence inducing insecticides have recorded higher BPH/MB ratio. The increase in the ratio of BPH/MB suggested adverse impact of insecticides on natural enemies, which may resulted in greater multiplication of the BPH. On the other hand, more favourable ratio of BPH/MB was observed in the plots treated with monocrotophos (5.49), acephate (5.35), buprofezin (3.10), cartap hydrochloride (5.25), pymetrozine (2.67) and fipronil (2.96) indicating their safety towards predatory mirid bug.

Effect of insecticides on the population of spiders during *rabi* 2016-17

The population of spiders ranged from 12.67 to 20.33 per 20 hills in different treatments at ten days after spray and found statistically significant. Pymetrozine (18.50 Nos./20 hills), buprofezin (18.67 Nos./20 hills), fipronil (18.67Nos./20 hills), chlorantraniliprole (18.17 Nos./20 hills), monocrotophos (18.50 Nos./20 hills), acephate (18.17 Nos./20 hills) and cartap hydrochloride (17.67 Nos./20 hills) registered higher population of spiders and statistically on par with each other and also with control. While, deltamethrin (13.83 Nos./20 hills), imidacloprid (13.33 Nos./20 hills), profenophos (12.67 Nos./20 hills), cypermethrin (13.83 Nos./20 hills), lambda cyhalothrin (13.50 Nos./20 hills), bifenthrin (13.33 Nos./20 hills) and chlorpyriphos (13.00 Nos./20 hills) recorded significantly lower population of spiders as compared to control (20.33 Nos./20 hills) (Table 2).

Observations made on the population brown planthopper, mirid bug and spiders in the present study, chlorpyriphos and profenophos can induce resurgence in the population of BPH and this can be attributed to high values of BPH/MB ratio which often results in suppression of the predatory mirid bug and less number of spiders thus leading to rise in population of BPH. The present findings are in agreement with observations made by Venkatreddy *et al*. (2015) [16], who observed the decline of the population of mirid bug and spiders were closely associated with lambda cyhalothrin and chlorpyriphos induced resurgence in brown planthopper. Rao *et al*. (2016) [13] also reported the application of chlorpyriphos, lambda cyhalothrin and profenophos caused resurgence in the population of rice brown planthopper. Jhansilakshmi *et al.* (2006) [5] also demonstrated that profenophos and ethion expressed moderate to severe toxicity against mirid bug specific to BPH. Based on the results obtained in the present field studies, cypermethrin, deltamethrin, bifenthrin and lambda cyhalothrin belonging to synthetic pyrethroid group can induce resurgence in BPH. The present findings also reported the negative impact of synthetic pyrethroids on green mirid bug and spiders as evidenced by high prey predator (BPH/MB) ratio values which often results in suppression of the predatory mirid bug thus leading to rise in population of BPH.

Based on the results obtained in the present investigation, imidacloprid can induce resurgence in the population of BPH and this can be attributed to the adverse effect of imidacloprid on the population of mired (high BPH/MB ratio values) and spiders. This was in agreement with reports of Jhansilakshmi *et al*. (2001) [7].

Table 1: Effect of resurgence causing insecticides on natural enemies of brown planthopper during *kharif* 2016

Treatment	Dose (g or ml/ha)	Cumulative population of BPH (Mean of three sprays) (No./20 hills)	Resurgence ratio	Cumulative population of MB (Mean of three sprays) (No./20 hills)	Prey predator (BPH/MB) ratio	Cumulative population of Spiders (Mean of three sprays) (No./20 hills)
Chlorpyriphos 50 EC	800 ml	177.50	1.64	30.83	5.78 (2.40)d	8.33 (2.89)bc
Acephate 75 SP	750 g	62.67	0.58	17.67	3.62 (1.90)e	15.17 (3.88)a
Profenophos 50 EC	1000 ml	192.67	1.78	32.17	6.27 (2.50)bcd	8.50 (2.91)bc
Monocrotophos 36 SL	800 ml	62.67	0.58	17.33	3.86 (1.96)e	15.17 (3.86)a
Cartap Hydrochloride 50 SP	1000 g	61.33	0.57	16.17	3.96 (1.99)e	15.00 (3.87)a
Cypermethrin 10 EC	500 ml	189.50	1.75	33.83	5.80 (2.40)d	8.50 (2.92)bc
Deltamethrin 2.8 EC	500 ml	189.50	1.75	32.67	6.06 (2.46)cd	7.83 (2.74)c
Bifenthrin 10 EC	500 ml	198.50	1.84	26.50	7.73 (2.77)abc	10.17 (3.20)b
Lambda cyhalothrin2.5 EC	500 ml	196.17	1.82	28.00	8.16 (2.83)a	8.33 (2.89)bc
Imidacloprid 17.8 SL	125 ml	190.67	1.77	27.17	8.10 (2.82)ab	8.33 (2.88)bc
Chlorantraniliprole 18.5 SC	150 ml	62.83	0.58	29.33	2.07 (1.42)g	14.67 (3.82)a
Fipronil 5 SC	1000 ml	68.50	0.63	16.00	4.36 (2.06)e	13.67 (3.67)a
Buprofezin 25 SC	800 ml	42.50	0.39	13.67	3.20 (1.78)ef	14.33 (3.77)a
Pymetrozine 50 WG	300 g	28.00	0.26	12.17	2.35 (1.53)fg	15.00 (3.86)a
Untreated Control	Water Spray	108.00	-	27.67	3.90 (1.97)e	16.33 (4.02)a
C.D (0.05)					0.32	0.41
C.V (%)					8.87	7.24
F test					Sig.	Sig.

Figures in parentheses are square root transformed values; Resurgence ratio suggested by Heinrichs *et al*. (1981) [4]

> 1 indicates resurgence; < 1 indicates no resurgence;In a column, means followed by a common letter are not significantly different by LSD (P=0.05)

Table 2: Effect of resurgence causing insecticides on natural enemies of brown planthopper during *rabi* 2016-17

Treatment	Dose (g or ml/ha)	Cumulative population of BPH (Mean of three sprays) (No./20 hills)	Resurgence ratio	Cumulative population of MB (Mean of three sprays) (No./20 hills)	Prey predator (BPH/MB) ratio	Cumulative population of Spiders (Mean of three sprays) (No./20 hills)
Chlorpyriphos 50 EC	800 ml	2256.00	2.56	155.83	13.52 (3.67)a	13.00 (3.60)b
Acephate 75 SP	750 g	74.00	0.08	14.33	5.35 (2.31)f	18.17 (4.25)a
Profenophos 50 EC	1000 ml	2815.00	3.19	273.00	8.89 (2.97)cde	12.67 (3.54)b
Monocrotophos 36 SL	800 ml	101.33	0.11	19.33	5.49 (2.34)f	18.50 (4.23)a
Cartap Hydrochloride 50 SP	1000 g	262.67	0.30	50.83	5.25 (2.29)f	17.67 (4.20)a

Cypermethrin 10 EC	500 ml	4385.67	4.97	519.67	7.83 (2.80)^{e}	13.83 (3.71)^{b}
Deltamethrin 2.8 EC	500 ml	6246.33	7.08	530.00	10.34 (3.21)^{bcd}	13.83 (3.71)^{b}
Bifenthrin 10 EC	500 ml	9190.67	10.42	637.33	11.76 (3.41)ab	13.33 (3.65)b
Lambda cyhalothrin 2.5 EC	500 ml	8947.33	10.14	667.17	11.06 (3.31)^{bc}	13.50 (3.75)^{b}
Imidacloprid 17.8 SL	125 ml	1519.83	1.72	162.50	8.71 (2.94)^{de}	13.33 (3.64)^{b}
Chlorantraniliprole 18.5 SC	150 ml	216.00	0.24	68.33	3.35 (1.82)^{g}	18.17 (4.26)^{b}
Fipronil 5 SC	1000 ml	76.00	0.09	26.00	2.96 (1.72)^{g}	18.67 (4.32)^{a}
Buprofezin 25 SC	800 ml	71.50	0.08	27.17	3.10 (1.75)^{g}	18.67 (4.32)^{a}
Pymetrozine 50 WG	300 g	25.67	0.03	10.17	2.67 (1.63)^{g}	18.50 (4.30)^{a}
Untreated Control	Water Spray	882.00	-	164.00	5.51 (2.35)^{f}	20.33 (4.51)^{a}
C.D (0.05)					0.35	0.44
C.V (%)					8.19	6.64
F test					Sig.	Sig.

Figures in parentheses are square root transformed values; Resurgence ratio suggested by Heinrichs *et al*. (1981) [4];>1 indicates resurgence; <1 indicates no resurgence

In a column, means followed by a common letter are not significantly different by LSD (P=0.05)

Conclusion

It is evident from the present investigation that the suppression of natural enemies considered as an important factor associated with resurgence in the population of brown planthopper. Hence, it is advised to avoid or minimize the usage of resurgence inducing insecticides in rice ecosystem.

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