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Research Article

FACTOR INFLUENCING THE RESURGENCE OF BROWN PLANTHOPPER IN BANGLADESH

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ABSTRACT

Possible causes of brown plant hopper resurgence were determined at the net-house of Entomology Division of Bangladesh Rice Research Institute (BRRI) during 2015. Causes of resurgence in the form of resurgence ratios were higher with acetamiprid, acephate, chlorpyrifos, cypermethrin, deltamethrin, fenvalerate, lambda cyhalothrin, thiamethoxam insecticides compared to imidacloprid, cartap, dinotefuran, isoprocarb /MIPC, phenthoate, pymetrozine when even applied at recommended dose. However, thiamethoxam, imidacloprid, isoprocarb / MIPC and cartap applied at sub-lethal dose produced higher resurgence ratio of BPH than others. Isoprocarb / MIPC, a commonly used recommended insecticide was found to have a higher resurgence ratio with the insecticide treatment at the egg stage (1.71) and combination of all stages (0.82). These insecticides influenced on the growth and reproductive physiology of rice brown planthopper and consequently resurgence ratio ranged increased.

Keywords: Brown planthopper, Dose, Insecticide, Resurgence, Stage

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important crops providing a staple food for more than half of the global population (Muthayya et al., 2014). A large complex of pest organisms, consisting of insects, vertebrates, disease and weeds, have been associated with rice for hundreds of years (Islam and Catling, 2012). There are more than 232 insects (Ali et al., 2017) and several vertebrate pest species, which cause damage to the rice plants (Islam et al., 2003). Out of this large complex, about 20-30 species may be considered as the major pests and these have the potential to cause significant yield loss (Krishnaiah et al., 2008). Among the pests infesting rice, the brown planthopper (BPH), *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae)

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has gained major importance in several Asian countries including Bangladesh. The loss in grain yield ranges from 10 to 70% (Liu and Sun, 2016). It is also a vector in transmitting viral diseases such as grassy stunt, ragged stunt and wilted stunt (Cabauatan et al., 2009). In Bangladesh rice crops worth at least US$ 8.1 million were lost due to BPH attack during the last three widespread outbreaks in 1976, 1978 and 1983 (Alam and Karim, 1986). Nowadays its outbreak is occurring frequently in different areas of Bangladesh (Ali et al., 2014), Sri Lanka (Sivasubramaniam and Imthiyas, 2018) and many other countries.

The control of this insect pest has always been emphasized and largely relied on insecticides in most rice producing countries (Ali et al., 2019) especially in countries where commercial, resistant varieties are not available. All the pesticides have different types of effect on the pest, which may lead to the differential development of the next generation of the pest (Volodymyr et al., 2018). Heavy uses of broad-spectrum chemicals also reduce the biodiversity of natural enemies, lift the natural control, induce outbreak of secondary pests and contaminate ecosystem (Ali et al., 2019). Continuous use of insecticides has resulted in BPH resistance to insecticides (Wu et al., 2018) and its outbreaks.

Resurgence is one of the major causes for BPH outbreak. After application of insecticides, its resurgence was reported in Bangladesh (Alam, 2013), India (Ghosal and Chatterjee, 2018), the Philippines (Heong and Hardy, 2009) and the Poland (Wojciechowska et al., 2016). In insecticide trials in experimental stations and in farmer`s fields, hopper burn commonly occurs in treated plots while untreated areas remain relatively free of infestation (FAO, 2006). Existing literatures suggest that resurgence of BPH take place after application of some insecticides (Alam, 2013; Wojciechowska et al., 2016) that killed natural enemies (Bommarco et al., 2011) while on the other hand, it could be because of stimulated fecundity of certain pests after the applications of some insecticides (Wang et al., 2005). Improper methods of application of some insecticides also caused resurgence. To find out the reasons for resurgence of BPH, an experiment was planned, designed and conducted in the net house conditions.

MATERIALS AND METHODS

The trial was conducted at entomology net house of Bangladesh Rice Research Institute during 2015. The trial cage consisted of a steel frame covered with fine mesh wire screen. The size of the cage was 152 × 66 × 84 cm. It consisted of three chambers. The size of each chamber was 51 × 65 × 84cm. The cage bottom was open and placed on a tray made of steel (183 × 91 × 15 cm). Standing water was maintained in the tray. The tray with cage was placed in an iron frame (183 × 76 × 76 cm). Twenty-five to 30-day-old plants were used as experimental units. Each pot contained three hills and the number of tillers per pot ranged from 40-50. The plants in the pot were cleaned by removing dried, diseased and insect infested leaves.

Before imposing treatments, it was also confirmed that plants were free from eggs of any insects. Each pot was covered by Mylar cage of height 76.2 cm and diameter 50.4 cm. Ten gravid BPH female were introduced in each Mylar cage followed by closing the top with net. The gravid female within the pots were allowed to lay egg for 48 hours. Egg bearing pot was kept in chamber. Three pots were introduced in each chamber, which was considered as a replication. In all growth stages, BPH were collected from rearing chamber and released into experiment chamber (*ca*. 100/pot). Burned tillers bearing pots were replaced by fresh tiller bearing pots during study period as and when necessary. The partition of each chamber was covered by thick polythene sheet in order to keep the original condition of each chamber. This experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each chamber with three pots was considered as one replication of a treatment, and each room treated as one block.

Effect of different insecticides on the development of BPH resurgence

Fourteen groups of single molecule containing chemical insecticides were applied at recommended dose (Table 1). Fresh water was applied on the plants of control treatments. Hand sprayer (Seesa hand pressure sprayer) was used to spray insecticide.

Table 1. Name of the insecticides with concentration used in the treatments

Treatment	Name of insecticide	Recommended dose (g or ml/L water)
T_1	Acetamiprid (Tundra 20 SP)	0.25 g
T_2	Acephate (Mimpahte 75 SP)	1.50 g
T_3	Imidacloprid (Admire 20 SL)	0.25 ml
T_4	Cartap (Suntap 50 SP)	2.40 g
T_5	Chlorpyrifos (Dursban 20 EC)	2.00 ml
T_6	Cypermethrin (Cymbaz 10 EC)	1.00 ml
T_7	Deltamethrin (Decis 2.5 EC)	1.00 ml
T_8	Dinotefuran (Token 20SG)	0.30 g
T_9	Fenvalerate (Fenfen 20 EC)	0.50 ml
T_{10}	Isoprocarb/MIPC (Chabi 75 WP)	2.60 g
T_{11}	Lambda cyhalothrin (Karate 2.5 EC)	1.00 ml
T_{12}	Phenthoate (Kiron 50 EC)	2.00 ml
T_{13}	Pymetrozine (Plenum 50 WG)	0.60 g
T_{14}	Thiamethoxam (Spike 25 WG)	0.12 g
T_{15}	Control	Only water

Effect of different doses of selected insecticides on resurgence development

Three doses *viz.* lower, recommended and higher dose of five selected insecticides were sprayed in an experimental arena as treatment with the help of a hand sprayer. A control experimental site was also maintained which was sprayed with fresh water only (Table 2).

Table 2. Name of the treatments of insecticides with different doses

Treatment	Insecticide	Low, recommended and higher dose (g or ml/L water)
T_1	Imidacloprid (Admire 20 SL)	0.20 ml
T_2	Imidacloprid (Admire 20 SL)	0.25 ml
T_3	Imidacloprid (Admire 20 SL)	0.30 ml
T_4	Cartap (Suntap 50 SP)	2.20 g
T_5	Cartap (Suntap 50 SP)	2.40 g
T_6	Cartap (Suntap 50 SP)	2.80 g
T_7	Isoprocarb/MIPC (Chabi 75 WP)	2.20 g
T_8	Isoprocarb/MIPC (Chabi 75 WP)	2.60 g
T_9	Isoprocarb/MIPC (Chabi 75 WP)	2.80 g
T_{10}	Pymetrozine (Plenum 50 WG)	0.30 g
T_{11}	Pymetrozine (Plenum 50 WG)	0.60 g
T_{12}	Pymetrozine (Plenum 50 WG)	0.90 g
T_{13}	Thiamethoxam (Spike 25 WG)	0.10g
T_{14}	Thiamethoxam (Spike 25 WG)	0.12 g
T_{15}	Thiamethoxam (Spike 25 WG)	0.14 g
T_{16}	Control	Only water

Effect of insecticides on different stages of BPH for the possible resurgence development

Different stages of BPH, such as T_1= egg, T_2= 1^{st}-2^{nd} instar nymph, T_3= 3^{rd}-4^{th} instar nymph, T_4= adult and T_5= combination of all stages was used as the treatment. Specific arena was developed according to treatment. A control chamber (T_6) was also maintained consisting all growth stages of BPH. Isoprocarb / MIPC insecticide (Chabi 75 WP) was applied in each chamber at the rate of 2.6 g/L of water. The control chamber was sprayed with fresh water.

Data Collection: The BPH populations were recorded before imposing treatments through counting. The BPH populations were recorded after 72 hours and 30 days of spraying. The resurgence ratio of BPH was calculated by the following equation (Heinrichs et al., 1981):

$$\text{Resurgence ratio} = \frac{\text{Population after application of insecticide}}{\text{Population in check field at the same interval}}$$

Statistical analysis: The collected data were arranged as required for statistical analysis. The software program STATISTIX 10 was selected to analysis the data as it is reported to be more efficient in analyzing entomological data. The mean differences among the treatments were determined by LSD test.

RESULTS AND DISCUSSION

Effect of different insecticides on the development of BPH resurgence

The number of BPH/pot was not significantly different among the treatments before insecticide spray (Table 3), although it varied significantly after 72 hours and one month of spraying. The data of table 3 clearly showed that the resurgence ratio was significantly higher in T_6 (2.06) followed by T_7, T_1, T_{11} and T_9. Moderate resurgence ratio was found in T_{14} (1.07) and it was not significantly different with resurgence ratio of T_2 (1.03) and T_5 (1.02). The lowest resurgence ratio was found in T_8 and T_{13} (0.25 to 0.26) followed by T_{12} (0.71), T_4 (0.82), T_{10} (0.83) and T_3 (0.96). T_8 and T_{13} were almost identical and T_4, T_{10} were not significantly different among them.

Table 3. Effect of single molecule containing insecticides on resurgence development

Treatment		Recommended dose (g or ml/L water)	No. of BPH/pot at different time intervals			Resurgence ratio
			Before spray (pretreatment)	After 72 hours of spray	After one month of spray	
T_1	Acetamiprid (Tundra 20 SP)	0.25 g	109.33a	50.00b	212.67bc	1.38bc
T_2	Acephate (Mimpahte 75 SP)	1.50 g	109.33a	17.33f	159.00de	1.03d
T_3	Imidacloprid (Admire 20 SL)	0.25 ml	110.67a	37.00	149.00f	0.96e
T_4	Cartap (Suntap 50 SP)	2.40 g	110.33a	10.67g	126.67g	0.82f
T_5	Chlorpyrifos (Dursban 20 EC)	2.00 ml	110.33a	10.67g	157.33e	1.02d
T_6	Cypermethrin (Cymbaz 10 EC)	1.00 ml	109.67a	49.00b	318.33a	2.06a

Treatment		Recommended dose (g or ml/L water)	No. of BPH/pot at different time intervals			Resurgence ratio
			Before spray (pretreatment)	After 72 hours of spray	After one month of spray	
T_7	Deltamethrin (Decis 2.5 EC)	1.00 ml	109.67a	48.00b	215.67b	1.40b
T_8	Dinotefuran (Token 20SG)	0.30 g	110.00a	3.00i	39.00i	0.25h
T_9	Fenvalerate (Fenfen 20 EC)	0.50 ml	109.33a	79.00a	206.67c	1.34c
T_{10}	Isoprocarb/MIPC (Chabi 75 WP)	2.60 g	110.00a	10.67g	129.00g	0.83f
T_{11}	Lambda cyhalothrin (Karate 2.5 EC)	1.00 ml	111.33a	25.67e	210.00bc	1.36bc
T_{12}	Phenthoate (Kiron 50 EC)	2.00 ml	108.00a	17.33f	109.33h	0.71g
T_{13}	Pymetrozine (Plenum 50 WG)	0.60 g	109.67a	6.67h	40.00i	0.26h
T_{14}	Thiamethoxam (Spike 25 WG)	0.12 g	107.67a	32.00d	165.00d	1.07d
T_{15}	Control	Only water	108.00a	79.67a	154.67ef	-
Level of significance			NS	**	**	**
$LSD_{0.05}$			9.92	3.29	6.98	0.05
CV%			5.41	6.19	2.62	2.97

**= Significant at 1% level of probability, *= Significant at 5% level of probability

NS= Non-Significant, Values in a column followed by different letters are significantly different

With increased adoption of new high yielding varieties, use of insecticides were also increased and the destruction of predators and parasitoids that followed insecticide misuse resulted in resurgence of several rice pests including the BPH, *Nilaparvata lugens* (Heinrichs and Mochida, 1984). Anand et al. (2019) conducted an experiment with seven insecticides *viz*., chlorpyriphos, profenophos, cypermethrin, deltamethrin, bifenthrin, lambda cyhalothrin and imidacloprid on the growth and reproductive physiology of rice brown planthopper. They reported that bifenthrin, cypermethrin, lambda cyhalothrin and deltamethrin resulted in enhancement of fecundity of brown planthopper (227.67, 218.33, 199.00 and 191.00 nymph's *vs*. 131.00 nymphs in control) and consequently resurgence ratio ranged from 1.18 to 1.74. Chlorpyriphos, cypermethrin, deltamethrin, bifenthrin and lambda cyhalothrin also significantly increased the nymphal survival (86.67 per cent to 96.00 per cent against 80.67 per cent in control) and growth index (6.34 to 7.11 vs 5.63 in control).

Effect of different doses of selected insecticides on development of BPH resurgence

The data clearly showed that the number of BPH/pot was not significantly different (104 to 107) among the treatment before spray (Table 4) that differed significantly after 72 h and one month of spraying. The resurgence ratio was highest in T_{13} (1.61) followed by T_1 (1.39) and then T_{14} (1.30), T_7 (1.26) and T_4 (1.22). T_{13} was significantly different with other treatments but T_{14} and T_7 were insignificant. Resurgence ratio in T_{15}, T_{10}, T_2, $T_{9,}$ T_3 and T_5 were 1.08, 1.02, 0.98, 0.97, 0.92, 0.91 and 0.91, respectively. Significantly the lowest resurgence ratio was found in T_{12} (0.65) and T_{11} (0.69) followed by T_6 (0.84). T_{12} and T_{11} were insignificantly different among them but significantly different with T_6.

Use of insecticide at lower dose is common in farmers' practice as it saves some money apparently. The practice of using low dose combined with short residual toxicity of many commercial insecticides may often cause the sub-lethal effect to the pest. The result is in conformity with the earlier findings (Heinrichs et al., 1982; Chelliah and Uthamasamy, 1986; Karns and Stewart, 2003. Heinrichs et al. 1982) and reported high BPH populations (40-fold) with lower application rates of FMC 3500 (0.2 kg a.i./ha) as compared to high rate (1.0 kg a.i./ha). Chelliah (1979) reported that low doses of resurgence-inducing insecticides increased the reproductive rate of the BPH and reduced the nymphal duration, eventually leading to resurgence. Heinrichs and Mochida (1984) reported that dose rates had a distinct effect on the degree of resurgence in both the decamethrin and methyl parathion treatments with the higher rates permitting the higher BPH populations. There were 850 BPH per hill at the high and 210 BPH per hill at the low decamethrin rate and 60 BPH per hill in the check. Present findings showed 20-50% increase in the levels of resurgence when low dose was used. Further lower dose might increase the resurgence ratio to some higher degree. The efficacy study of isoprocarb/MIPC showed it was an effective insecticide but when applied with sub-lethal dose was found to be developed resurgence. It clearly indicates that any recommended product or chemical could also be cause of resurgence development under improper doses. Bao et al. (2009) conducted an experiment on the effects of sublethal doses of four insecticides viz. triazophos, fenvalerate, imidacloprid and dinotefuran on the reproduction of BPH. Imidacloprid and dinotefuran reduced the fecundity of BPH to 68.8% and 52.4% in macropterous families, and to 57.9% and 43.1% in brachypterous families, when compared with the untreated controls. By contrast, triazophos and fenvalerate increased fecundity and consequently resurgence ratio increased.

Table 4. Effect of different doses of selected insecticides on resurgence development

Treatment		Low, Recommended and higher dose (g or ml/L water)	No. of BPH/pot at different time intervals			Resurgence ratio
			Before spray (Pre-treatment)	After 72 hours of spray	After one month of spray	
T_1	Imidacloprid (Admire 20 SL)	0.20 ml	104.67a	52.67bc	192.67b	1.39b
T_2	Imidacloprid (Admire 20 SL)	0.25 ml	104.00a	49.00c	136.33fg	0.98fg
T_3	Imidacloprid (Admire 20 SL)	0.30 ml	103.67a	30.00de	127.67gh	0.92gh
T_4	Cartap (Suntap 50 SP)	0.20 g	104.33a	47.00c	169.67d	1.22d
T_5	Cartap (Suntap 50 SP)	2.40 g	105.67a	11.00g	126.33h	0.91h
T_6	Cartap (Suntap 50 SP)	2.80 g	104.00a	8.00g	117.00i	0.84i
T_7	Isoprocarb/MIPC (Chabi 75 WP)	2.20 g	103.67a	23.00ef	174.67cd	1.26cd
T_8	Isoprocarb/MIPC (Chabi 75 WP)	2.60 g	104.00a	13.00g	126.33h	0.91h
T_9	Isoprocarb/MIPC (Chabi 75 WP)	2.80 g	104.67a	11.33g	135.00fgh	0.97fgh
T_{10}	Pymetrozine (Plenum 50 WG)	0.30 g	104.67a	29.00de	142.00ef	1.02ef
T_{11}	Pymetrozine (Plenum 50 WG)	0.60 g	105.00a	15.00fg	96.33j	0.69j
T_{12}	Pymetrozine (Plenum 50 WG)	0.90 g	103.67a	16.00fg	90.67j	0.65j
T_{13}	Thiamethoxam (Spike 25 WG)	0.10g	104.00a	60.33b	223.33a	1.61a
T_{14}	Thiamethoxam (Spike 25 WG)	0.12 g	103.67a	50.33c	180.00c	1.30c
T_{15}	Thiamethoxam (Spike 25 WG)	0.14 g	104.33a	32.00d	150.00e	1.08e
T_{16}	Control	Only water	106.67a	79.67a	139.00f	-
Level of significance			NS	**	**	**
$LSD_{0.05}$			7.86	8.71	9.00	0.06
CV%			4.51	15.85	3.71	3.69

**= Significant at 1% level of probability, *= Significant at 5% level of probability
NS= Non-Significant, Values in a column followed by different letters are significantly different

Effect of insecticide on different stages of BPH for the development of resurgence

Five different growth stages including combination of all stages were sprayed with a most common insecticide— Isoprocarb/MIPC (Chabi 75 WP) for the development of resurgence (Table 5). In treatment $T_{1,}$ the number of BPH/pot was nil (only bearing eggs) and there was no significant difference among the treatments (T_2 to T_6) before insecticide application. After 72 hours of spraying, significantly the highest number of BPH was found in control treatment; but after one month it was significantly higher with T_1 (303) followed by T_6 (178). Zero population was found in T_2 and T_3 treatments. Resurgence ratio was also significantly higher in T_1 (1.71) treatment compared to other treatments. But no significant difference was found betweenT_4 (0.78) and T_5 (0.82) treatments.

Table 5. Effect of isoprocarb/MIPC (Chabi 75 WP) on different stage of brown planthopper for the development of resurgence

Treatment		No. of BPH/pot at different time intervals			Resurgence ratio
		Before spray (pre-treatment)	After 72 hours of spray	After one month of spray	
T_1	Egg	0.00b	0.00d	303.00a	1.71a
T_2	1^{st}-2^{nd} instar nymph	97.00a	1.67cd	0.00d	0.00c
T_3	3^{rd}-4^{th} instar nymph	100.00a	5.00c	0.00d	0.00c
T_4	Adult	98.67a	15.67b	138.00c	0.78b
T_5	Combination of all stages	100.00a	19.00b	144.44c	0.82b
T_6	Combination of all stages (control)	99.67a	84.33a	177.67b	-
Level of significance		**	**	**	**
$LSD_{0.05}$		4.97	4.99	24.30	0.19
CV%		3.31	13.09	10.5	15.4

**= Significant at 1% level of probability, *= Significant at 5% level of probability

NS= Non-Significant, Values in a column followed by different letters are significantly different

Many researchers reported that the effectiveness of insecticide depends on the stage of the insect. The reproductive rates of BPH exposed to insecticide-sprayed plants during nymphal or adult stage or both varied significantly (Chelliah, 1979). The reproductive rate was significantly higher when the BPH was exposed to plants sprayed with resurgence-inducing insecticides at the fourth-and fifth-instar stage as well as the adult stage (Chelliah, 1979). The result of the present study clearly showed that the nymph of the BPH was more susceptible to insecticides than the egg and adult stages. Therefore, care should be taken to apply insecticides depending on stage of the pest. There may be a requirement to spray the crop again after a few days to kill the early insects of pest developed from the primary sprayed egg.

CONCLUSION

The insecticide namely acetamiprid, acephate, chlorpyrifos, cypermethrin, deltamethrin, fenvalerate, lambda-cyhalothrin, thiamethoxam were responsible for higher resurgence of BPH. In contrast, imidacloprid, cartap, dinotefuran, isoprocarb/MIPC, phenthoate, pymetrozine showed low resurgence producing potentials. So, recommendation of insecticides for controlling BPH that produce low resurgence require special attention in selecting right dose at the right time because they may cause high resurgence of BPH when used at sub-lethal dose. A similar high resurgence was evident with insecticide treatment at egg and adult stage. There may be a requirement to spray the crop again after a few days to kill the early insects of pest developed from the primary sprayed egg.

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