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Effect of insecticides on the feeding and fecundity of rice brown planthopper, *Nilaparvata lugens* (Stål)

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Abstract

Stimulatory effect of some insecticides on feeding and reproductive rate of rice brown planthopper *Nilaparvata lugens* (Stål) was investigated in the laboratory experiment during *kharif* 2020 and *rabi*, 2020-21 at RARS, Maruteru, Andhra Pradesh. Brown planthopper excreted significantly higher amount of honeydew on deltamethrin (278.67mm^2) and fipronil (231.17mm^2) treated rice plants. Deltamethrin also resulted in enhancement of reproductive rate of BPH and consequently resulted in resurgence (resurgence ratio>1), whereas the remaining insecticides *i.e*., flubendiamide, chlorantraniliprole (foliar and granular), fipronil, carbofuran and cartap hydrochloride did not influence the reproductive rate of BPH (resurgence ratio<1). Hence, insecticides barring deltamethrin can be used judiciously against insect pests of rice with periodical monitoring for development of resistance and induction of resurgence.

Keywords: Brown planthopper, resurgence, reproductive rate, fecundity, insecticides, feeding rate, rice, honey-dew excretion, *Nilaparvata lugens*

Introduction

Among the insect pests infesting rice, brown planthopper (BPH), *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae) is considered as the major yield limiting factor in all the rice growing countries both in tropics and temperate regions (Krishnaiah, 2014). Both the nymphs and adults of the BPH suck plant sap from phloem cells resulting in "hopper burn" symptoms and it can cover large circular patches in the rice fields under heavy pest pressure. Besides direct feeding damage, it also serves as vector for rice grassy stunt and rice ragged stunt viruses (Hibino, 1990).

Farmers rely solely on insecticides for the management of planthoppers and almost 50% of the insecticides used in rice are targeted against BPH alone (Reddy *et al*., 2012). But their repeated applications often result in problems such as development of insecticide resistance, residues in the farm produce and environmental contamination. Besides this, insecticides may affect the physiology of the target insect pests directly through stimulation of growth and reproduction or indirectly through the alteration in the nutritional quality of host plant that leads to increased feeding and may result in resurgence of the BPH (Chelliah and Heinrichs, 1980). Application of fipronil significantly increased the quantity of honeydew excreted by BPH (Ling *et al.,* 2009).

Suri *et al.,* (2015) reported that deltamethrin, methyl parathion and quinalphos significantly enhanced the reproductive rate of brown planthopper and consequently resulted in higher resurgence ratio. Synthetic pyrethroids like bifenthrin, cypermethrin, lambda cyhalothrin and deltamethrin resulted in enhancement of fecundity of brown planthopper (227.67, 218.33, 199.00 and 191.00 nymphs' vs 131.00 nymphs in control) and consequently resurgence ratio ranged from 1.18 to 1.74 (Anand Kumar *et al*., 2019). Keeping this in view, the present laboratory study was undertaken to investigate the stimulatory effects of some insecticides that are most frequently being used in rice ecosystem on feeding and reproduction of brown planthopper.

Materials and Methods

A laboratory experiment in completely randomized design (CRD) was conducted in poly-house of the Department of Entomology, Regional Agricultural Research Station (RARS), Maruteru, West Godavari District of Andhra Pradesh during *kharif* 2020 and *rabi* 2020-21.

Brown planthopper (BPH), *Nilaparvata lugens* (Stal) was reared on one month old potted plants of the susceptible rice variety, Taichung Native-1 (TN1) to obtain large number of nymphs and adults of brown planthopper of uniform size and age required for different experiments. Planthopper susceptible rice variety, Swarna (MTU 7029) was used as test variety in the experimentation. The insecticides *viz*., Flubendiamide 20WG, Chlorantraniliprole 18.5SC, Fipronil 5SC, Deltamethrin 2.8EC, Carbofuran 3G, Chlorantraniliprole 0.4G and Cartap hydrochloride 4G including untreated control were used to study their impact on feeding and fecundity of BPH. Emulsions of test insecticides were prepared at recommended doses from the commercial formulations by adding required quantities of water. A pot with one hill represented one replication and each treatment was replicated thrice. Insecticides were applied twice at 20 and 35 days after planting as per the procedure described for resurgence test by Heinrichs *et al*., (1981). The quantity of granular insecticides per pot (surface area of the pot used was 0.025 m^2) was calculated based on the recommended field rate (carbofuran @ 62.5 mg/pot, chlorantraniliprole @ 25 mg/pot and cartap hydrochloride @ 50 mg/pot). The weighed insecticides were incorporated into the soil around the plants in pots with 2 cm standing water and the plants were sprayed with water alone as control.

1) Influence of insecticides on feeding rate of BPH

The relative feeding preference of BPH between insecticide treated and untreated rice plants (control) was assessed indirectly by estimating the amount of honeydew excreted by the adult planthoppers as an indication of the feeding rate (feeding index) adopting the technique developed by Pathak and Heinrichs (1980). Fifteen days after second spray of foliar insecticides and thirty days after second round application of granular insecticides, tillers of each plant were thinned out retaining only one tiller in each pot. The culm was passed through a hole in the centre of the card board sheet. A polythene sheet was placed on the card board to prevent moisture absorption by the filter paper. Whatman No.1 filter paper was made into 9.00 cm diameter circles with a small hole in the centre and a longitudinal cut from the margin to the centre. These filter paper circles were dipped in bromocresol green solution (2 mg bromocresol green powder/1 ml of ethanol) and allowed to dry for one hour and dipped again till the filter paper circles turned to yellowish orange. The treated filter paper circle was then kept over polythene sheet placed on the card board present at the base of potted plant. Plastic cup containing a hole at the centre was placed in an inverted position over the single potted plant. Two freshly emerged adult female hoppers, pre-starved for two hours were released into the cup through the hole and the hole was plugged with non-absorbent cotton to prevent escape of the insects. The BPH adults were allowed to feed for 24 hours at the base of the stem. The honey-dew droplets excreted by the adults, when come in contact with the filter paper turn into blue spots. The filter paper was removed 24 hours after the commencement of feeding and the total area of the blue spots appeared on each filter paper was measured using Image - J software (Rashband, 1997) and expressed as area of honeydew excretion in mm^2 per two females.

2) Influence of insecticides on fecundity of BPH

At 15 days after second spray of foliar insecticides and 30 days after second application of granular insecticides, one pair of adult BPH were released per pot, confined therein for seven days for oviposition and later the insects were removed. To assess the impact of insecticides on reproductive rate (fecundity) of BPH, the nymphs that hatched in each pot were counted daily and removed with aspirator. This process was continued until hatching terminated. The total number of nymphs that hatched on plants treated with insecticides serves as an indirect measure of fecundity of the brown planthopper. Nil mortality of BPH was recorded in all the treatments during resurgence test period.

The resurgence of brown planthopper following the application of each test insecticide was assessed from the comparison of fecundity on the treated and control plants as per the formula given by Heinrichs *et al.,* (1981).

$$\text{\# Resurgence ratio} = \frac{\text{Mean number of BPH nymphs in the treatment}}{\text{Mean number of BPH nymphs in the control}}$$

<1 - No resurgence ; >1 – Resurgence

Statistical Analysis

Data recorded on feeding rate and fecundity were converted into square root transformations and then subjected to analysis of variance technique (ANOVA) (Gomez and Gomez, 1984). The treatment means were compared by Least Significant Difference (LSD) method.

Results and Discussion

1. Feeding Rate (Feeding Index)

Results relating to the effect of insecticides on feeding rate of BPH during *kharif* 2020 are presented in Table 1. Insecticidal treatments had significantly influenced the BPH feeding and honey-dew excretion. The highest feeding rate of BPH was observed on the plants treated with deltamethrin 2.8EC (224 mm^2) and is significantly superior over untreated control (112 mm^2). It was followed by fipronil 5SC (182 mm^2), chlorantraniliprole 18.5SC (132 mm^2) and flubendiamide 20WG (122 mm^2) which were at par with untreated control. Other test insecticides, chlorantraniliprole 0.4G, carbofuran 3G and cartap hydrochloride 4G registered lower feeding rate of 57, 32 and 19 mm^2, respectively in descending order and significantly lower than the untreated check.

During *rabi* 2020-21 also **(Table1),** insecticidal application significantly influenced the BPH feeding and honeydew excretion. Deltamethrin 2.8EC recorded the highest area of honeydew excretion (333.33 mm^2) and was significantly superior to that of untreated check (201.67 mm^2). It was followed by fipronil 5SC (280 mm^2), chlorantraniliprole18.5SC (185 mm^2), flubendiamide 20WG (153.33 mm^2) and carbofuran 3G (133.33 mm^2) which were at par with untreated control. Granular insecticides, chlorantraniliprole 0.4G and cartap hydrochloride 4G registered lower honeydew excretion of 130 and 121.67 mm^2, respectively in descending order and significantly lower than the untreated check.

Table 1. Effect of insecticides on the feeding rate of BPH during *kharif* 2020 and *rabi, 2020*-21

T. No.	Treatment	Dose (ml l^{-1} or kg/ha)	Feeding rate@ (area of honeydew excreted in mm^2)		
			***Kharif* 2020**	***Rabi*, 2020-21**	**Mean**
T_1	Flubendiamide 20 WG	0.25 ml/l	122 (10.98) b	153.33 (12.25) cd	137.70 (11.63) bc
T_2	Chlorantraniliprole18.5 SC	0.3 ml/l	132 (11.47) b	185 (13.38) cd	158.62 (12.47) b
T_3	Fipronil5 SC	2.0 ml/l	182 (13.30) ab	280 (16.72) ab	231.17 (15.18) a
T_4	Deltamethrin 2.8 EC	1.0 ml/l	224 (14.87) a	333.33 (18.21) a	278.67 (16.67) a
T_5	Carbofuran 3G	25.0 kg/ha	32 (5.61) cd	133.33 (11.51) cd	82.44 (9.06) d
T_6	Chlorantraniliprole 0.4 G	10.0 kg/ha	57 (7.47) c	130 (11.38) d	93.74 (9.68) cd
T_7	Cartap hydrochloride 4G	20.0 kg/ha	19 (4.36) d	121.67 (11.00) d	70.42 (8.37) d
T_8	Untreated control	Water spray	112 (10.55) b	201.67 (14.18) bc	156.83 (12.51) b
F test			**Sig.**	**Sig.**	**Sig.**
LSD (0.05)			**2.74**	**2.78**	**2.08**
CV (%)			**16.12**	**11.87**	**10.10**

*Mean of three replications; figures in parentheses are square root transformed values.
@ by 2 adult BPH /24 hours
In a column, means followed by a common letter are not significantly different by LSD (P=0.05)

The mean data of two seasons (*kharif*, 2020 and *rabi*, 2020-21) revealed that, deltamethrin 2.8EC (278.67 mm^2) and fipronil 5SC (231.17 mm^2) registered higher feeding rate of BPH and is significantly superior to untreated control (156.83 mm^2). This was followed by chlorantraniliprole 18.5SC (158.62 mm^2) and flubendiamide 20WG (137.70 mm^2) which were at par with untreated control. Rest of the granular insecticides, chlorantraniliprole 0.4G (93.74 mm^2), carbofuran 3G (82.44 mm^2) and cartap hydrochloride 4G (70.42 mm^2) registered lower honeydew excretion of BPH, respectively in descending order which are significantly lower than the untreated check.

Insecticides are known to have stimulatory or inhibitory influences on feeding of planthoppers in rice. Higher feeding of brown planthopper on deltamethrin and fipronil treated plants as reported in honeydew test might be due to the increased levels of sugars and free amino acids in treated plants compared to untreated rice plants which needs to be confirmed through biochemical analysis of leaf sheaths for sugars and amino acids. Higher feeding of BPH on deltamethrin in the present studies are in agreement with the observations of Chelliah and Heinrichs (1980); Raman and Uthamasamy (1983) and Yi and Choi (1986), who also reported increased feeding rate of BPH on TN1 rice plants treated with deltamethrin, methyl parathion, diazinon, quinalphos, cypermethrin, fenthion and permethrin over the control. Suri and Singh (2009) also reported that methyl parathion, deltamethrin, quinalphos and imidacloprid applied to potted rice plants resulted in enhancement of feeding of whitebacked planthopper. Enhanced feeding of BPH on fipronil treated rice plants is supported by Ling *et al.,* (2009).

2. Reproductive rate (Fecundity) of BPH

Data on reproductive rate of BPH during first season, *kharif* 2020 revealed that insecticides significantly influenced reproductive rate of BPH adults when they were allowed to feed and oviposit on the insecticide treated plants **(Table 2).** The highest reproductive rate of BPH was observed on deltamethrin 2.8EC with 107 nymphs emerged per one pair of adult hoppers and was superior over untreated control (68 nymphs). It was followed by cartap hydrochloride 4G, carbofuran 3G, and flubendiamide 20WG treated plants with 84, 65.33 and 56.67 nymphs emerged per one pair of adult hoppers, respectively and on par with untreated control. While, chlorantraniliprole 18.5SC, chlorantraniliprole 0.4G and fipronil 5SC recorded significantly lower fecundity compared to control.

Resurgence ratio of BPH feeding on deltamethrin 2.8EC was 1.57 indicating the risk associated with the use of this insecticide leading to failure in control of the planthoppers. Other test insecticides recorded a resurgence ratio of less than one.

During second season, *Rabi* 2020-21, the highest reproductive rate of BPH was noticed in deltamethrin 2.8EC with 98.33 nymphal emergence per one pair of adult hoppers and was significantly superior to untreated control (57.00 nymphs). Other treatments, *viz*., flubendiamide 20WG, chlorantraniliprole 0.4G, chlorantraniliprole 18.5SC, carbofuran 3G, cartap hydrochloride 4G and fipronil 5SC treated plants registered 36.67, 30.67, 25.33, 23.67, 22.00 and 16.33 nymphs per one pair of adult hoppers, respectively and significantly lower than control.

Deltamethrin 2.8EC registered a resurgence ratio of greater than one (1.73) resulting in flare up of BPH population. Other test insecticides recorded a resurgence ratio of less than one (<1). Based on the mean data of two seasons (*kharif*, 2020 and *rabi*, 2020-21), the highest reproductive rate of BPH was observed on deltamethrin 2.8EC (102.67 nymphs emerged per one pair of adult hoppers) which is superior to untreated control (62.50 nymphs). While, other insecticides registered lower fecundity (Resurgence ratio <1) indicating that they can be used judiciously for the management of insect pests in rice ecosystem.

Table 2. Effect of insecticides on the fecundity of BPH during *kharif* 2020 and *rabi,* 2020-21

T. No.	Treatment	Dose (ml l^{-1} or kg/ha)	Kharif 2020		Rabi, 2020-21		Mean	
			Reproductive rate (No. of nymphs hatched) @	Resurgence Ratio	Reproductive rate (No. of nymphs hatched) @	Resurgence Ratio	Reproductive rate (No. of nymphs hatched)@	Resurgence Ratio
T_1	Flubendiamide 20 WG	0.25 ml/l	56.67 (7.51) cd	0.83	36.67 (6.05) c	0.64	46.67 (6.82) c	0.75
T_2	Chlorantraniliprole18.5 SC	0.3 ml/l	46.00 (6.75) de	0.68	25.33 (5.02) de	0.44	35.67 (5.96) de	0.57
T_3	Fipronil5 SC	2.0 ml/l	14.33 (3.75) f	0.21	16.33 (4.02) f	0.29	15.33 (3.89) f	0.25
T_4	Deltamethrin 2.8 EC	1.0 ml/l	107.00 (10.32) a	1.57	98.33 (9.90) a	1.73	102.67 (10.13) a	1.64
T_5	Carbofuran 3G	25.0 kg/ha	65.33 (8.07) bc	0.96	23.67 (4.85) de	0.42	44.50 (6.66) cd	0.71
T_6	Chlorantraniliprole 0.4 G	10.0 kg/ha	38.33 (6.16) e	0.56	30.67 (5.53) cd	0.54	34.50 (5.86) e	0.55
T_7	Cartap hydrochloride 4G	20.0 kg/ha	84.00 (9.14) b	1.24	22.00 (4.68) ef	0.39	53.00 (7.27) bc	0.85
T_8	Untreated control	Water spray	68.00 (8.25) bc		57.00 (7.54) b	-	62.50 (7.91) b	
F test			**Sig.**		**Sig.**		**Sig.**	
LSD (0.05)			**1.22**		**0.81**		**0.73**	
CV (%)			**9.38**		**7.78**		**6.11**	

*Mean of three replications; @ from eggs laid by 1 female in 7 days, figures in parentheses are square root transformed values. In a column, means followed by a common letter are not significantly different by LSD (P=0.05)

The present findings of higher fecundity rate of BPH on rice plants treated with deltamethrin is in conformity with the observations of several workers (Heinrichs *et al.*,1982; Zhu *et al*., 2004; Suri and Singh, 2011; Suri *et al.,*2015), who reported the reproductive stimulation as an important factor for causing resurgence in populations of BPH and WBPH. This increase in fecundity might be attributed to the stimulation of planthopper reproduction by the insecticide residues or their metabolites, chemical changes in the host plant receiving insecticides, or a combination of these two factors.

Conclusions

Based on the results from the present study, deltamethrin not only resulted in increased feeding rate but also enhanced the fecundity of BPH and consequently resulted in resurgence in the population of brown planthopper. Thus, the use of deltamethrin against insect pests in rice ecosystem may be avoided or not recommended. Other insecticides *i.e*., flubendiamide 20WG, chlorantraniliprole (18.5SC and 0.4G), fipronil 5SC, carbofuran 3G and cartap hydrochloride 4G did not influence the reproductive rate of BPH (resurgence ratio <1). Hence, they can be used judiciously for the management of insect pests in rice ecosystem with periodical monitoring for the development of resistance and induction of resurgence.

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