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Toxicity of various insecticides against Delhi and Palla population of brown plant hopper (*Nilaparvata lugens)*

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ABSTRACT

Toxicity of different insecticides recommended to control brown plant hopper *Nilaparvata lugens* (Stal) was evaluated in the laboratory against insect populations collected from Delhi and in its surrounding village Palla. Results showed that endosulfan was most effective with lowest lethal concentrations being 0.0007% against both populations. The values of relative toxicity when calculated in comparison to LC_{50} value of monocrotophos it was observed that acetamiprid, thiamethoxam, flubendamide, clothinidine and mixture of flubendamide + fipronil were less toxic than monocrotophos, whereas imidacloprid, chlorpyriphos and endosulfan were more toxic to *N. lugens.* Based on relative toxicity derived on the basis of LC_{50} and $LC_{97.5}$ values, endosulfan was highly toxic and most effective insecticides among the insecticides tested.

Key words: Bioassay, Delhi, *Nilaparvata lugens,* Palla strain, Susceptibility, Toxicity

Brown plant hopper [*Nilaparvata lugens* (Stal)] is one of the most menacing insect pests of rice (*Oryza sativa* L.) among various leafhoppers and plant hopper species. The Brown plant hopper was a minor pest in most tropical countries of Asia earlier. Following the introduction of insecticides and modern semi-dwarf rice varieties, *N. lugens* became most devastating insect pest of rice in Asia and large-scale damage by this pest has been reported from India, Indonesia, Phillipines, Sri Lanka and Bangladesh. Brown plant hopper *N. lugens* is mainly a pest of irrigated rice but it can also become abundant in rainfed environment and upland rice. At low infestation of this insect, plant height, crop vigour, tiller production reduces, whereas heavy infestation turns plants yellow, which dry up rapidly. At early infestation round yellow patches appear, which soon turn brownish due to drying up of the plants. Since this insect generally remain confined to plant stems and leaf sheaths, its presence goes undetected. The dry brown spots in the lush-green paddy field known as hopper burn are often the first visible symptoms, which spread very fast if not controlled. Under severe infestation, circular patches of hopper burn are evident in the field. Severely affected plants do not bear any grains. The most commonly practical method of controlling brown plant hopper is through application of insecticides.

Regular intermittent rains right from summer months until September during 2008 led to high humidity and optimal temperature, which resulted in rapid multiplication of rice plant hoppers and widespread outbreak of brown plant hopper during September–October 2008 in northern India. Farmers from nearby Delhi area reported failure of some insecticides, especially neonicotinoids against these pests even at double the recommended concentration (IARI 2008). The degree of outbreak/resurgence is influenced by insecticide management practices (application rate, number, method, volume of spray and timing of application) and level of varietal and insectical resistance to brown plant hopper (Haque *et al.* 2002). During outbreaks, insecticides and varietal resistance provide the immediate and acceptable solutions to ward off devastating damage with near total crop losses. This outbreak may be due to increased tolerance developed by the insects against sprayed insecticides accomplished to generate basic information which could be utilized for assessing the level of tolerance. In the absence of any base line data it was difficult to assess the level of susceptibility. Therefore, the present study was conducted to assess the relative toxicity and expected effective concentration of insecticides including conventional insecticides as well as neonicotinoids against plant hopper population collected from rice fields of IARI farm and Palla village of Delhi.

MATERIALS AND METHODS

For bioassay studies adult brown plant hopper, *N. lugens* were collected from rice fields of Indian Agricultural Research Institute, and nearby village Palla, Delhi. With the

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help of atomizer, adult insects were transferred and kept in plastic jars with green twigs and tillers of the plants. These jars were covered with muslin cloth and kept in the laboratory for 4–6 hr before experiments so that insects can acclimatized in the laboratory atmosphere. Both populations were kept separately so that the insects cannot intermingle with each other.

Commercial formulations of different insecticides, viz. Imidacloprid 17.8 SL, Acetamiprid 20 SP, Thiamethoxam 25 WG, Flubendamide 39.35 SC, Endosulfan 35 EC, Monocrotophos 36 WSC, Clothianidine 50 WDG, Buprofezin 25 EC, Chlorpyriphos 20 EC, Flubendamide +Fipronil 66WG, Fipronil 5 SC were used for bioassay. Different concentrations were prepared in the tap water and control was kept with water only. Preliminary range tests were conducted with a number of concentrations. Seven concentrations were used in final bioassay.

Twenty-days-old green tillers were obtained from the field and cut into equal (6 cm length) pieces. These pieces of tillers were dipped in different concentrations of insecticides for 15 sec. The treated tillers were kept on aluminium foil to dry up for 15 min. and placed in 60 ml test tubes with the help of forceps. Four such tillars were kept in each tube. Ten adult brown plant hoppers were released in each tube and covered with perforated lids. Treated tillers with adult insects were kept in insect culture room at 27±1ºC temperature and 70±2% relative humidity. Each concentration and control was replicated thrice. Mortality was observed 24 hr after treatment and moribund insects were treated as dead. Mortality in all the treatments was corrected by Abott's formula (Abott 1925). The LC_{50} value was calculated by analyzing the data using computer based Probit Analysis Programme Indostat. LC_{50} and $LC_{97.5}$ values of Delhi population was compared with Palla village population to determine that whether brown plant hopper could have developed resistance to treated insecticides.

RESULTS AND DISCUSSION

On the basis of LC_{50} values against Delhi population of adult brown plant hopper the order of toxicity for insecticides

Table 1 Toxicity of various insecticides against *Nilaparvata lugens (*Delhi population)

Insecticide	Heterogeneity		Regression equation	LC_{50}(%)	Fiducial limit	$LC_{97.5}$(%)	Fiducial limit
	χ2	*df*					
Imidacloprid 17.8 SL	7.304	4	6.919+0.760x	0.0030	0.0021–0.0043	0.8626	0.2189–4.2552
Acetamiprid 20 SP	9.060	4	5.937+0.591x	0.0237	0.0173–0.0326	0.5001	0.1695–1.4750
Thiamethoxam 25 WG	4.880	4	6.943+1.053×	0.0134	0.0065–0.0312	0.3466	0.0675–2.0395
Fipronil 5 SC	2.645	3	7.3663+0.939×	0.0030	0.0018–0.0050	0.3694	0.0233–5.8668
Flubendamide 39.35 SC	1.263	3	5.614+1.416×	0.3685	0.2253–0.6029	8.9283	1.6169–9.3065
Endosulfan 35 EC	0.228	3	21.860+5.367×	0.0007	0.0006–0.0008	0.0017	0.0012–0.0023
Monocrotophos 36 WSC	3.330	4	7.192+0.972×	0.0056	0.0031–0.0102	0.5788	0.0707–4.7356
Clothianidin 50 WDG	3.419	4	7.289+1.275×	0.0160	0.0111–0.0231	0.5522	0.1874–1.6272
Buprofezin 25 EC	1.839	4	7.491+1.107×	0.0056	0.0036–0.0089	0.3319	0.0481–2.2914
Flubendamide+ Fipronil 66WG	0.882	4	7.803+1.341x	0.0081	0.0057–0.0116	0.2355	0.0620–0.8944
Chlorpyriphos 20 EC	1.559	5	11.261+2.144×	0.0015	0.0011–0.0019	0.0114	0.0066–0.0196

Table 2 Toxicity of various insecticides against *Nilaparvata lugens-(*Palla population)

Insecticide	Heterogeneity		Regression equation	LC_{50}(%)	Fiducial limit	$LC_{97.5}$(%)	Fiducial limit
	χ2	*df*					
Imidacloprid 17.8 SL	4.808	5	6.954+0.735×	0.002	0.0016–0.0030	0.963	0.2181–4.2552
Acetamiprid 20 SP	9.928	5	6.950+1.165×	0.0212	0.0146–0.0309	1.0212	0.2447–4.2620
Thiamethoxam 25 WG	5.704	3	8.012+1.471x	0.0091	0.0052–0.0142	0.1928	0.0315–1.1989
Fipronil 5 SC	1.986	3	7.228+0.917×	0.0037	0.0021–0.0065	5.5105	0.0269–9.7013
Flubendamide 39.35 SC	1.263	3	5.614+1.416×	0.3685	0.2253–0.6029	8.9283	1.6169–9.3065
Endosulfan 35 EC	0.507	4	20.264+4.798×	0.0007	0.0005–0.0007	0.0017	0.0012–0.0025
Monocrotophos 36 WSC	5.214	4	7.897+1.183×	0.0036	0.0223–0.0055	0.1615	0.0397–1.6575
Clothianidin 50 WDG	3.412	4	7.283+1.265×	0.0158	0.0110–0.0230	0.5532	0.1866–1.5232
Buprofezin 25 EC	2.496	4	7.365+1.029×	0.0051	0.0032–0.0081	0.4046	0.0343–2.2022
Flubendamide+ Fipronil 66 WG	2.501	4	7.818+1.274×	0.0061	0.0043–0.0087	0.2122	0.0546–0.8252
Chlorpyriphos 20 EC	2.204	3	10.043+1.753×	0.0013	0.0009–0.0018	0.0172	0.0081–0.0366

evaluated was endosulfan> chlorpyriphos> fipronil> imidacloprid> monochrotophos = buprofezin> flubendamide + fipronil> thiamethoxam> clothianidin> acetamiprid. Whereas for adult brown plant hopper of Palla village the order of toxicity was endosulfan> chlorpyriphos> imidacloprid> monocrotophos = buprofezin> fipronil> flubendamide + fipronil> thiomethoxam> clothianidin> acetamiprid (Tables 1, 2). The difference in susceptibility between Delhi and Palla population was 1.50 times for imidacloprid, 1.75 times for acetamiprid, 1.47 times for thiomethoxam, 0.45 times for fipronil, 1 for flubendamide and endosulfan, 1.55 times for monocrotophos, 1.01 times for clothianidin, 1.10 times for buprofezin,1.32 times for mixture of flubendamide + fipronil and 1.15 times for chlorpyriphos (Table 3).

However, at $LC_{97.5}$ level the toxicity of insecticides differed and in ascending order and it was flubendamide < imidacloprid < monocrotophos < clothianidin < acetamiprid < fipronil< thiamethoxam < buprofezin < mixture of flubendamide + fipronil < chlorpyriphos < endosulfan for Delhi population. For Palla strain order of toxicity of insecticides was similar except Imidacloprid, Acetamiprid and Monocrotophos. Relative toxicity of insecticides when calculated in comparison to LC_{50} value of monocrotophos it was observed that acetamiprid, thiamethoxam, flubendamide, clothinidine and mixture of fubendamide + fipronil were less toxic than monocrotophos, whereas imidacloprid, chlorpyriphos and endosulfan were more toxic. Based on relative toxicity derived on the basis of LC_{50} and $LC_{97.5}$ values the most toxic and effective insecticides was endosulfan.

Generally, it is accepted that field application rates should at least be 20 folds or more as compared to LC_{50} value for providing satisfactory control of pest in agriculture (Misra 1989). By this simple logic expected effective dosages (g ai/ha/500 litre) of the all 12 insecticides were calculated (Table 3). The computed dosages were compared with the recommended field doses of insecticides and it was observed that for the neonicotinoids which are being widely used showed decreased toxicity. However, conventional insecticides proved to be effective even at doses lower than the recommended one. Thus comparison of the expected effective doses of evaluated insecticides based on their LC_{50} value with recommended dose revealed a pronounced shift in the susceptibility level of *N. lugens* except conventional insecticides. One of the reasons for change in susceptibility to insecticides may be the over use of neonicotinoids against brown plant hopper. There are several reports of development of resistance against neonicotinoids in brown plant hopper, *N. lugens* (Stal) (Hemiptera: Delphacidae), such as in Thailand and later on found in Asian countries. Positive cross resistance between Imidacloprid and Thiamethoxam was also observed. Maximum tolerance of brown plant hopper for Fipronil was also reported from Japan, Taiwan, China, Vietnam and Phillipines (Matsmura *et al.* 2008).

However, detailed studies are needed to further confirm the development and resistance in *N. lugens* in India. Population of brown plant hopper in China, Japan, Taiwan and Vietnam registered 40–120 fold resistance to imidacloprid (Bentur and Viraktmath 2008). Due to continuous and indiscriminate use of neonicotinoids over last few years, frequent control failures by this class of insecticide

Table 3 Comparison of effective field dosages with recommended dosages of different insecticides against *Nilaparvata lugens*-Delhi and Palla population

Insecticide	Based on LC_{50} values				Based on $LC_{97.5}$ values				E.E.Dg a i/ha		R.D (g a i/ha)	Increase/ decrease	
	Relative toxicity of insecticides		Relative susceptibility of insect		Relative toxicity of insecticides		Relative susceptibility of insect						
	D	P	D	P	D	P	D	P	D	P		D	P
Imidacloprid 17.8 SL	1.86	1.80	1.00	1.50	0.67	0.16	1.00	0.89	300.0	200.0	25.0	12	8
Acetamiprid 20 SP	0.23	0.16	1.00	1.75	1.15	0.15	1.00	0.48	2370.0	2120.0	25.0	94.8	84.8
Thiamethoxam 25 WG	0.41	0.39	1.00	1.47	1.60	0.83	1.00	1.79	1340.0	910.0	50.0	26.8	18.2
Fipronil 5 SC	2.15	0.63	1.00	0.45	0.65	0.29	1.00	14.9	300.0	370.0	50.0	6.00	7.40
Flubendamide 39.35 SC	0.01	0.009	1.00	1.00	0.065	0.018	1.00	1.00	36850.0	36850.0	25.0	1474.	1474
Endosulfan 35 EC	8.00	5.14	1.00	1.00	340.47	95.00	1.00	1.00	70.0	70.0	385.0	0.18	0.18
Monocrotophos36 WSC	1.00	1.00	1.00	1.55	1.00	1.00	1.00	3.58	560.0	360.0	400.0	1.40	0.90
Clothianidin 50 WDG	0.35	0.22	1.00	1.01	1.04	0.29	1.00	0.99	1600.0	1580.0	15.0	106.6	105.3
Buprofezin25 EC	1.00	0.70	1.00	1.10	1.74	0.40	1.00	0.82	560.0	510.0	100.0	5.60	5.10
Flubendamide+ Fipronil 66WG	0.69	0.59	1.00	1.32	2.45	0.76	1.00	1.32	810.0	610.0	33.0	24.0	18.5
Chlorpyriphos 20 EC	3.7	2.76	1.00	1.15	50.77	9.38	1.00	0.66	150.0	130.0	500.0	0.30	0.26

EED, Expected effective dose; RD, recommended dose; D, Delhi population; P, Palla population became evident in South Indian states, especially in Andhra Pradesh and Karnataka. Further elaborative studies for resistance development are required (IRAC 2007).

The control failure of *N. lugens* in rice in India may be due to improper method of contact insecticidal spray on the plants, wherein insecticides could not reach the hoppers present on leaf sheaths and stems due to dense crop canopy. Therefore, pesticide sprays, especially with contact insecticides should be aimed at basal portion of plants. However, this becomes difficult during advanced crop growth stages, resulting in lower efficacy of insecticides. Regular monitoring and cultural methods are very important for plant hopper management. Provision of alleyways at 5 m interval to ensure proper aeration in the field and to facilitate pesticide application, alternate wetting and drying, and optimum and balanced use of fertilizers and manures can play an important role in their management. Besides, natural enemies of plant hoppers, such as spiders, predatory bugs and beetles also need to be conserved against harmful effects of broad spectrum pesticides. Safer formulation of insecticides such granules may be preferred as these pose less hazard to natural enemies. It is high time that this outbreak should strengthen the system of monitoring of insect infestation and right insecticide/application technology for pest management. Therefore, very high population of plant hoppers coupled with tolerance to neonicotinoids/failure of insecticides, especially contact ones to reach the target due to dense crop canopy and death of natural enemies due to indiscriminate use of insecticides may be responsible for heavy production losses in rice.

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