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Short Communication

Assessment of the field efficacy of dinotefuran 20 SG against brown planthopper (*Nilaparvata lugens* Stål) in basmati rice

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Rice (*Oryza sativa* L.), is one of the most important cereal crops of the world, which occupies foremost status in human food requirements. More than 90 per cent of the worlds' rice is grown and consumed in Asia, where 60 per cent of the worlds' population lives. India is the largest rice growing country of the world. The productivity of rice in India is quite low (3.01 tons ha^{-1}) as compared to world average of 4.02 tons ha^{-1} (Anonymous, 2012). Among the various factors, insect-pests cause serious losses in yield of rice in India. About 100 insect species are known to attack rice crop and 20 of them are consistently reported as major pests (Rahaman and Stout, 2019). Since introduction of high-yielding varieties, distinct changes have been occurred in the insect-pest complex of rice in India. Brown planthopper, *Nilaparvata lugens* Stål is one of the major problems in irrigated conditions. Injudicious use of insecticides and chemical fertilizers by the farmers favours the rapid build up of insect populations resulting in reduction in the biodiversity of natural enemies, secondary pest outbreaks, pesticide residues in grains and environmental degradation. Brown planthopper is probably the most devastating pest of rice in India causing huge crop losses to the tune of 10-70 percent (Ghosh *et al*., 2014). The nymphs and adults of the pest cause a reduction in the plant growth by sucking cell sap resulting in wilting and leaf chlorosis. Collectively these symptoms cause 'hopper burn. In spite of having the substitutes for chemical control strategies, none has found effective in controlling brown planthopper. Selection and use of insecticides that are effective against target pests and less toxic to the non-target species are of prime importance in the IPM strategies. Besides, pesticide residue is another important issue while exporting the food commodities at global level. Recently, Indian exports have been facing rejection due to multiple factors including non-adherence to food safety requirements known as sanitary and phytosanitary standards (SPS), detection of pesticide residues beyond prescribed Maximum Residue Limit (MRLs) etc. (Mukherjee *et al.,* 2019). Continuous stress on green alternatives prompted the necessity of introduction of newer and more potent but safer molecules of pesticides that are quickly degradable in nature. In line with the above-mentioned directive principles, dinotefuran, a new furanicotinyl insecticide that represents the third generation of the neonicotinoid group was chosen as an effective alternate to manage the BPH in basmati rice. Dinotefuran is described as a non-mutagenic, non-neurotoxic or reproductive toxin and acts both through contact and ingestion, resulting in the cessation of feeding and ultimately the death of the target pest. Dinotefuran further acts as an agonist of insect nicotinic acetylcholine receptors, but it is postulated that it affects the nicotinic acetylcholine binding in a manner that differs from other neonicotinoid insecticides. Its mechanism of action involves disruption of the insect's nervous system by inhibiting nicotinic acetylcholine receptors which is unique as compared to the other insecticides of the neonicotinoid group. In addition, dinotefuran 20 SG is a registered insecticide against sucking pests by Central Insecticide Board & Registration Committee at a dose of 40 g a.i. ha^{-1}. Keeping theses points in consideration, an experiment was conducted to evaluate the efficacy of dinotefuran 20 SG against brown planthopper in basmati rice at farmers' fields.

Efficacy of dinotefuran 20 SG against brown planthopper in rice was tested at farmers' field during *Kharif*, 2019 in basmati varieties (CSR 30 & PB 1121), as both varieties have export value in market. Test insecticide was tested at 40g a.i. ha^{-1} (recommended dose by Central Insecticide Board & Registration Committee) and compared with untreated control. The crop was raised as per standard recommended package of practices of CCS Haryana Agricultural University, Hisar (Anonymous, 2019). However, tested insecticide for brown planthopper was applied in treated plots. The rice seedlings were transplanted during *kharif*, 2019 at farmers' fields. There were 6 multi-location trials (Karnal, Kurukshetra and Kaithal districts) with plot size of one acre per trial for treated and untreated control. Insecticide was sprayed with a knapsack sprayer twice or when pests crossed the economic threshold level i.e. 5-10 nymphs or adults per hill (Anonymous, 2019). Dilution of insecticide was made in 500 litres of water per hectare. Observations on brown planthopper (nymphs & adults) were recorded on ten randomly selected hills one day before application of the insecticide and at 5, 10 and 15 days after application and the data was presented as the average number of hoppers per hill. The yield was recorded separately from each field and then converted into per hectare basis. Cost: benefit ratio was calculated on basis of gross cost of cultivation and gross returns. While incremental cost: benefit ratio was calculated on basis of additional net income from insecticidal application and total cost of insecticide and its application. Phytotoxic effects caused by dinotefuran 20 SG were also recorded along with the control from ten randomly selected plants at 5, 10 and 15 days after spray (DAS) for the phytotoxicity symptoms *viz.,* leaf injury, vein clearing, leaf necrosis, leaf epinasty, yellowing, stunting and hyponasty on a scale of 0-10 (Ambarish *et al.*, 2017). Data was analyzed on basis of average population of brown planthopper at different intervals and decrease in hopper population over untreated control.

Data on brown planthopper (BPH) incidence recorded from 6 multi-location trials during *Kharif*, 2019 are presented in Tables 1 and 2. Results indicated that on an average 23.5 BPH/hill was recorded from treated plots one day before first insecticidal application, however, it was 23.1 BPH/hill in untreated plots from different locations. It indicates the uniform population in treated and untreated fields. Brown planthopper population ranged from 3.8 to 4.8 per hill at 5 days after first application of dinotefuran 20 SG @ 40 g a.i. ha^{-1} as compared to 19.2 to 28.5 BPH/hill in untreated control at various locations (Table 1). Corresponding figures for mean hopper population was 4.4 and 24.5 BPH/hill. Mean brown plant hopper population at 10 days after first spray of insecticide application was recorded 8.3 BPH/hill and 28.0 BPH/hill in untreated control. The population of BPH increased markedly in treated plots at 15 days after application of insecticide and it was recorded 11.2 /hill in comparison to 29.4/hill in untreated control (Table 1). Overall mean population of brown planthopper (15 days after spray) was recorded 8.0 BPH/hill in treated plots and it was 27.3 BPH/hill in untreated plots. Per cent reduction in brown planthopper population after first spray was recorded from 69.5 to 71.6 per cent with a mean of 70.7 per cent from different locations. Similar trend was recorded in brown planthopper population after second insecticidal spray (Table 2). It was 11.2 BPH/hill (treated plots) in comparison to 29.4 BPH/hill in untreated control one day before application of second spray. Mean population (4.1 BPH/hill) was reported at 5 days after application of second spray as compared to untreated control (28.0 BPH/hill). Infestation of brown planthopper slightly increased at 10 days after application of second insecticidal spray. The mean population was 4.6 BPH/hill in treated plots as compared to 27.2 in untreated control (Table 2). The overall mean per cent reduction (after 15 DAS) in brown planthopper count over untreated control was 84.0 per cent after the second spray. After the application of two sprays, dinotefuran 20 SG @ 40 g a.i. ha^{-1}, there was drastic reduction in hopper population as compared to control. Kumar *et al.* (2017) have demonstrated the effectiveness of dinotefuran 20 SG for control of brown planthopper and reported that population of BPH was recorded 3.58 per hill in spray of dinotefuran 20 SG @ 200g ha^{-1} as compared to 14.11 per hill in control. Findings of Seni and Naik (2017) who also observed that effectiveness of dinotefuran 20

SG for minimizing the plant hoppers population in rice support present results. Findings of Seni (2019) who further observed that dinotefuran 20 SG @ 200 g ha-^{1} was found to be the most effective treatment for control of plant hoppers with mean population of 36.00 and 27.00 numbers per 10 hills in *kharif* 2017 and 2018, respectively and was significantly superior to control (145.67 per 10 hills and 98.67 per 10 hills in 2017 and 2018, respectively) further strengthen findings of present investigations. Dinotefuran 20 SG at 30 g a.i. ha^{-1} was also found most effective in managing the population of sucking pests like leafhopper, *Amrasca biguttula* in okra crop (Venkateshalu and Math, 2017). During the present studies, dinotefuran 20 SG @ 40 g a.i. ha^{-1} did not inflict any phytotoxicity symptoms on the rice crop after both sprays, a fact also corroborated by the studies of Patil *et al.* (2017) and Singh *et al.* (2018) in paddy. The results of the multi-location trials exhibited higher rice yield in the insecticide-treated plots as compared to the control. Mean yield (38.1 q ha^{-1}) in dinotefuran 20 SG treated plots at the dose of 40 gm a.i. ha^{-1} was recorded as compared to the control (32.2 q ha^{-1}) during *Kharif*, 2019 (Table 3). Increase in yield over untreated control was recorded 18.4 per cent. Findings of Kumar *et al.* (2017) who recorded mean yield (56.26 q ha^{-1}) in dinotefuran 20 SG treated plots @ 40 gm a.i. ha^{-1} as compared to control (34.53 q ha^{-1}) support results of present investigations. Our results indicate that cost: benefit ratio was recorded to be 2.46 in plots where insecticide was applied as compared to 2.12 in untreated control plots. Incremental cost benefit ratio in dinotefuran 20 SG @ 40 g a.i. ha^{-} was recorded to be 1: 6.25 (Table 3). There is no mention in the literature with regard to cost: benefit and incremental cost benefit ratio in rice crop for brown planthopper. However, the present findings corroborate the findings of Rahaman and Stout (2019) for yellow stem borer control in rice reported a maximum cost-benefit ratio of 5.69 in the case of dinotefuran 20 SG. Mandal *et al.* (2013) also observed the highest cotton seed yield in the dinotefuran treated plot (10.88 q ha^{-1}) @ 40 g a.i. ha^{-1} followed by at 30 g (10.08 q ha^{-1}). Similarly, Venkateshalu and Math (2017) also found the maximum yield of okra fruits (93.01 q/ha) in the plots sprayed with dinotefuran 20 SG at 30 and 25 gm a.i. ha^{-1} (93.01 and 89.33 q/ha, respectively). Differences in yield and incremental cost benefit ratio by previous workers may be due to variety or environmental conditions prevailing at time of experimentation.

Table 1. Efficacy of dinotefuran 20% SG on incidence of brown planthopper in rice under farmers, field trials during Kharif, 2019 (first spray)

Locations	**Village**	**District**	**Variety**	**Population of BPH/hill**								**Mean BPH population/hill**		**Per cent decrease in BPH population over UC**
				Before spray		**5 DAS**		**10 DAS**		**15 DAS**				
				T	**UC**	**T**	**UC**	**T**	**UC**	**T**	**UC**	**T**	**UC**	
1	Indergarh	Karnal	CSR 30	22.5	23.4	3.8	24.3	9.8	26.2	10.3	29.7	8.0	26.7	70.0
2	Amargarh	Karnal	CSR 30	21.6	20.1	4.8	24.0	7.4	29.4	11.8	30.6	8.0	28.0	71.4
3	Rindal	Karnal	PB 1121	27.4	26.5	4.2	28.1	9.6	28.5	12.2	31.9	8.7	29.5	70.5
4	Amin	Kurukshetra	PB 1121	27.5	27.2	4.6	28.5	7.6	29.6	12.1	26.2	8.1	28.1	71.2
5	Teontha	Kaithal	CSR 30	19.7	18.3	4.8	19.2	8.2	27.8	10.4	29.7	7.8	25.6	69.5
6	Sakra	Kaithal	CSR 30	22.6	22.8	4.3	23.1	7.2	26.7	10.7	28.4	7.4	26.1	71.6
	Average			23.5	23.1	4.4	24.5	8.3	28.0	11.2	29.4	8.0	27.3	70.7

BPH: brown planthopper; DAS: Days after spray;T: Treated; UC: Untreated control

Table 2. Efficacy of dinotefuran 20% SG on incidence of brown planthopper in rice under farmers, field trials during Kharif, 2019 (second spray)

Locations	Village	District	Variety	Population of BPH/hill								Mean BPH population/hill		Per cent decrease in BPH population over UC
				Before spray		5 DAS		10 DAS		15 DAS		T	UC	
				T	UC	T	UC	T	UC	T	UC			
1	Indergarh	Karnal	CSR 30	10.3	29.7	4.6	28.4	4.9	28.2	3.8	25.8	4.4	27.5	84.0
2	Amargarh	Karnal	CSR 30	11.8	30.6	3.7	27.4	4.8	27.1	4.7	24.6	4.4	26.4	83.3
3	Rindal	Karnal	PB 1121	12.2	31.9	3.7	30.6	4.8	29.1	4.1	26.7	4.2	28.8	85.4
4	Amin	Kurukshetra	PB 1121	12.1	26.2	3.9	27.2	4.6	26.7	4.2	24.7	4.2	26.2	84.0
5	Teontha	Kaithal	CSR 30	10.4	29.7	4.3	26.9	4.5	25.1	4.0	23.5	4.3	25.2	82.9
6	Sakra	Kaithal	CSR 30	10.7	28.4	4.4	27.2	4.2	27.0	3.9	25.6	4.2	26.6	84.2
	Average			11.2	29.4	4.1	28.0	4.6	27.2	4.1	25.1	4.3	24.3	84.0

BPH: brown planthopper; DAS: Days after spray;T: Treated; UC: Untreated control

Table 3. Efficacy of dinotefuran 20 % SG on yield, cost : benefit ratio and incremental cost benefit ratio of rice under farmers, field trials during Kharif, 2019

Locations	Variety	Yield (q/ha)		Increase in yield over UC (%)	Cost : benefit ratio		Total cost/ha (Rs.)	Additional yield (q/ha)	Additional gross income /ha (Rs.)	Additional net income/ ha (Rs.)	Incremental cost: benefit ratio
		T	UC		T	UC					
1	CSR 30	35.4	29.2	21.2	2.48	2.12	2910	6.2	23808	20898	7.18
2	CSR 30	36.6	31.3	16.9	2.68	2.29	2910	5.3	20352	17442	5.99
3	PB 1121	42.7	36.4	17.3	2.16	1.94	2910	6.3	19688	16778	5.76
4	PB 1121	44.2	38.5	14.8	2.40	2.09	2910	5.7	17813	14903	5.12
5	CSR 30	34.2	28.7	19.2	2.48	2.08	2910	5.5	21120	18210	6.26
6	CSR 30	35.8	29.6	20.9	2.55	2.18	2910	6.2	23808	20898	7.18
Average		38.1	32.3	18.4	2.46	2.12	2910	5.87	21098	18189	6.25

T: Treated; UC: Untreated control; market rate of insecticides: dinotefuran 20 % SG @ Rs. 4275/kg; labour charge Rs. 600/ha for one spray; price of paddy grain: Rs. 3840/q (CSR 30), Rs. 3125/q (PB 1121)

Conclusion

It has been clearly observed from the present investigations that dinotefuran 20 SG @ 40 g a.i. ha^{-1} was the effective insecticidal treatment in reducing the brown planthopper population in rice when the pests crosses ETL with increased grain yield and no phytotoxicity on the paddy plant. Considering the incremental cost-benefit ratio, dinotefuran 20 SG @ 40 g a.i. ha^{-1} will be effective and economical for the control of brown planthopper in rice and it can be safely advocated for the use at farmer's fields.

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Compliance with ethical standards: NA

Conflict of interest: No

Authors' contributions

Designing of experiment, data collection, analysis and preparation of manuscript by both authors (MSJ & OPC).

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