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Bio-efficacy of new insecticidal molecules against plant hoppers in rice crop

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Abstract
The study was carried out during kharif seasons of 2020 and 2021 at different locations to assess the relative bioefficacy of new insecticidal molecules viz. Pexalon 10 SC (triflumezopyrim), Osheen 20 SG (dinotefuran), Chess 50 WG (pymetrozine) and Confidor 200 SL (imidacloprid) @ 235 ml, 500, 300 and 100 gm per hectare, respectively against plant hoppers (brown plant hopper and white backed plant hopper) in rice crop. The population of plant hoppers per hill was recorded before spray, 3, 7 and 10 days post treatment periods. It has been observed that all tested molecules are found significantly better and reduced (90.63-88.75%) the plant hoppers' population over control. Among, insecticidal treatments Osheen 20 SG showed superiority with least plant hoppers population [(1.10, 0.55, 0.56 (av. 0.74)] per hill and it was at par with each other insecticidal molecules. The maximum grain yield (72.45 q/ha) was obtained with application of Osheen 20 SG, however the highest cost: benefit (Rs. 1: 23) was achieved with application of Confidor (100 ml/ha). It was further observed that all the tested molecules have no ill effects on spider's population (Natural enemies).

Keywords: Among, bioefficacy, carried, cost-benefit, molecules, observed, population, significantly, spider, superiority, treatments

Introduction
Rice *(Oryza sativa* L*)* is one of the most important cereal crop and staple food for about half of the world's population. In Punjab, rice and basmati are major *kharif* crops and those occupied an area of 31.49 lakh ha, which was 70 per cent of total cultivated area of the state with a total annual production of 208.83 lakh tonnes (Anonymous 2022) [2]. To support the ever-increasing demand for higher grain yields, farmers around the world are increasing plant densities in their management schemes, which have resulted in an increased population of number of pests (Mekonnen *et al*., 2015; Kaur, *et al*., 2020) [16, 12]. The rice crop is also requires warm and humid climatic conditions from transplanting to maturity which is very conducive for development of insect-pests. Nearly 300 species of insect-pests have been reported in rice crop, among these only 23 species cause economic damage (Bhogadhi and Bentur, 2015; Kaur *et al*., 2020) [6, 12]. These insect-pests can be categorized according to their feeding habits like stem borers (yellow, white and pink stem borer), leaf feeders (leaf folder, rice hispa and grasshoppers), sap suckers (plant hoppers, green leaf hopper); root feeders (rice root weevil and termite) and others like rice ear cutting caterpillar (Sarao and Randhawa, 2022). The plant hoppers viz. brown plant hopper (*Nilaparvata lugens*) and white backed plant hopper (*Sogatella furcifera)* are major culprits for huge monetary losses to rice, basmati crops. The female planthoppers lay their eggs in leaf sheath tissues. Both nymphs and adults suck sap particularly from the leaf-sheath from July to October. The damaging symptoms start appearing from leaf tips and spread to the rest of the plant. The crop severely attacked by planthoppers ultimately dries up in patches. These dried up patches of the crop are called, 'hopper burn'. As the plants dry up, the hoppers migrate to the adjoining green plants and within a few days, the area of rusty patches enlarges. These hoppers also excrete honeydew as a result of which black sooty mould develops on the leaves, which impart smoky hue to the crop and hinder photosynthetic activities. These plant hoppers attack the rice crop from late vegetative stage to grains hardening stage. The plant hoppers also act as vector for viral diseases. (Atwal *et al*., 1997; Sarao and Randhawa, 2022) [4, 22]. The farmers rely heavily on insecticides for management of different insect-pests and almost 50% of the insecticides used in rice are targeted against these pests alone (Reddy *et al*., 2012) [21].

Among the various strategies adopted to combat the insec-pests of rice crop, insecticides are the first line of defence. Most of the insecticides used on rice crop are based on quite limited number of chemically different classes out of them the most important inorganic insecticides that are used against rice insect-pests belongs to synthetic pyrethroids and the indiscriminate use of these chemicals leads to adverse effects i. e. residues in rice grains, environmental contamination, resurgence, resistance and destruction of natural enemies which suggest the need to develop alternative management strategies (Dutta 2015; Brevik and Sauer, 2015; Ranga *et al*., 2007) [8, 20]. Hence, new molecules (green chemistry) are being added for there evaluation with an aim to least disruption of environmental qualities (Sarao and Randhawa 2019; Kaur *et al*., 2020; Sharma and Aggarwal 2014) [12, 25]. Therefore, an effort has been made in present investigation to evaluate the efficacy green chemistry insecticidal molecules against plant hopper in rice crop.

Materials and methods

The experiments for evaluation of different insecticidal molecules against plant hoppers in rice crop were conducted at PAU Regional Research Station and adjoining villages during kharif seasons of 2020 and 2021. The 35 days old nursery of cv. PR 121 was transplanted in third week of June during experimental years. The experiments were laid out with three replication and six treatments (insecticides, water spray and untreated control) in complete randomized block design (CRBD). The plot size of each treatment was kept 20 m^2, and buffers were maintained by 1.0, and 0.5 meter between replication and treatment plots, respectively maintained buffers. The crop was raised by following all recommended PAU practices except plant protection measures. The tested insecticidal molecules (Table 1) were sprayed by using 250 litres water per hectare at economic threshold level (5 plant hoppers per hill). The data on plant hoppers (*N. lugens* and *S. furcifera*) and natural enemies (spiders) population was enumerated on ten randomly selected hills of each treatment before spray, 3, 7 and 10 days after spray. At maturity, the crop was harvested with single plot thresher; grains were cleaned, dried and weighed separately of each plot and yield converted into per hectare. The recorded data of different locations and both years were pooled during the course of investigation were subjected to statistical analysis by using analysis of variance technique after square root transformations (yield data) as required (Sheoran *et al*., 1998) [26].

Table 1: The detail of tested insecticidal molecules

Treatment No.	Insecticidal molecule	Dose (ha)
T_1	Pexalon 10 SC (Triflumezopyrim 10 SC)	235 ml
T_2	Osheen 20 SG (Dinotefuran)	500 g
T_3	Chess 50 WG (Pymetrozine)	300 g
T_4	Confidor 200 SL (Imidacloprid)	100 ml
T_5	Water spray	-
T_6	Control	-

Results and Discussions

Efficacy of insecticidal applications against plant hoppers: The data of both experimental years (2020 and 2021) for rice plant hoppers (brown plant hoppers (*N. lugens)* and white backed plant hopper (*S. furcifera*) population was recorded per hill prior and 3, 7 and 10 days after spray with different treatments (insecticidal, water spray, untreated control) is presented in table 2. The recorded data indicated that plant hoppers population was uniformly distributed in all the experimental plots as it evident from the observations recorded before imposing of insecticidal spray. The results further revealed that there was significant ($p<0.05$) difference in live population of plant hoppers per hill sprayed with selected insecticidal molecules (p=0.05) at different post-treatment periods. The pooled data (Table 2 and Fig 1) of two years of both locations revealed that post treatment periods with 3, 7 and 10 days, the least mean live population 1.10, 0.55, 0.56, (av. 0.74) of plant hoppers per hill was observed when sprayed with Osheen 20 SG @ 500 g/ha it was closely followed by an application of Pexalon 106 SC (235 ml/ha), Chess 50 WG (300 g/ha) and Confidor (100 ml/ha) with hoppers population 1.05, 0.67.0.91 (av. 0.87); 1.15, 0.59, 0.97 (0.90) and 1.02, 0.87, 1.26, (av. 1.05) per hill at 3, 7, 10 days post treatment periods, respectively. In blank water spray and untreated control plots the live population of rice plant hopper per hill was recorded 8.29, 9.68, 9.48 (av. 9.15) and 8.57, 9.59, 9.74 (av. 9.30), respectively.

Reduction in hopper's population: The data ranged from 92.10 to 88.75 per cent (Table 2) on reduction of plant hoppers population per hill. The comparative effectiveness of insecticides molecules indicates that with application of Osheen 20 WG recorded highest reduction in plant hopper population (92.10 %,) followed by Pexalon 106 SC (90.63%), Chess 50 WG (90.29%) and Confidor 200 SL (88.75%) over untreated control. However, in blank water spray the negligible reduction (1.63 %) was observed. Therefore, it was observed that the new tested insecticidal molecules proved to be more essential insecticides against live population of rice plant hoppers.

Natural enemies (Spiders): The data (Table 3 & Fig. 2) on population of on natural enemies (spiders) from insecticidal treatments, water spray and untreated control plots were also recorded during both the years from all the locations pre and post treatment periods. It was observed that population of on natural enemies (spiders) prevailing very low and varied non-significantly at all the observation dates and all experimental pots. Therefore, it is assumed that tested insecticidal molecules under present study were found safest towards predator (spiders) of insect-pests of rice crop and has *no phytotoxic* effects were observed on rice crop.

Impact on grain yield and cost benefit ratio with application of tested molecules: The data (Table 4) on pooled (both years) grain yield per hectare ranged from 73.89 to 74.61 quintal with application of different green chemistry insecticidal molecules. The highest grain (unshelled) yield per hectare (74.61 q) was obtained with application of Osheen (500 g/ha) and it was on par with spray of Pexalon (74.36

qt/ha), Chess (74.28 q/ha) and Confidor (73.89 q/ha). The yield analysis of field experiment demonstrated the bioefficacy of green chemistry molecules in increasing significantly grain yield as compared to blank water spray (65.80 q/ha) and untreated control (65.42 q/ha). However, the highest cost: benefit (Table 4) was achieved with application of Confidor (100 ml/ha) i. e. Rs. 1: 23 and it was followed by Osheen 20 SG (500 g/ha) and Chess 50 WG with C: B @ Rs. 1:10 and 1:9. The least cost benefit ratio (Rs. 1: 4) was obtained with Pexalon 106 SC (235 ml/ha).

The present studies are in corroboration with the findings of Seni and Naik (2017) [24] who reported the effectiveness of dinotefuran in reducing planthopper population over control. The Pexalon (dinotefuran) has demonstrated excellent intrinsic activity against all the major rice hoppers and significantly reduced their honeydew excretion (Bhanu 2015; Kapasi *et al*., 2017 and Anonymous 2019) [5, 10, 1]. The observations of the present research work are also in congruence with the findings of Kumar *et al*. (2017) [15]; Sarao and Randhawa (2019) [23] reported that novel insecticides viz. triflumezopyrim 10.6 SC, dinotefuran 20 SG and pymetrozine 50 WG @ 237 ml, 200 g and 400 g/ ha, respectively were significantly better again rice plant hoppers. Similarly Patil *et al*., (2020) [18] observed 83 % reduction in population of brown plant hopper with application of Imidacloprid @ 0.20 ml per litre of water. The present findings are also in corroborate with Muralibhaskaran *et al*., (2009) [17] who also recorded 89.40 and 87.56 % decrease in plant hoppers' population with application of Chess 50 WG @ 400 and 350 g/ha, respectively. The results are also in close association with Guruprasad *et al*. (2016) who obtained the similar trends with application of different insecticides under transplanted rice field condition. Likewise, the Konchada *et al*., (2017) [13] reported that application of dinotefuran @ 30 g a.i./ha reduced 63 % brown planthopper's population over control and achieved second highest yield. The 55 per cent increase in grain yield over control was obtained with application of Imidacloprid (Arjun *et al*., 2017) [3]. Similarly, Kongchuensin and Takafuji (2006) [14] reported that dinotefuran was harmless to the predatory mite, *Neoseiulus longispinosus* (Evans).

Table 2: Field efficacy new insecticidal molecules against white backed plan hopper and brown planthopper infesting rice

Treatment No.	Plant Hopper population per hill days after spray																	
	2020						2021						Pooled					
	BS	3	7	10	Mean*	ROC (%)	BS	3	7	10	Mean*	ROC (%)	BS	3	7	10	Mean*	ROC (%)
T1	5.50	0.96	0.55	0.80	0.77	8.01	5.83	1.13	0.78	1.01	0.97	8.84	90.07	1.05	0.67	0.91	0.87	90.63
T2	5.59	1.00	0.43	0.53	0.65	8.13	5.96	1.19	0.67	0.59	0.82	8.99	91.68	1.10	0.55	0.56	0.74	92.10
T3	5.49	1.04	0.47	0.86	0.79	7.99	5.67	1.26	0.71	1.08	1.02	8.79	89.64	1.15	0.59	0.97	0.90	90.29
T3	5.45	0.96	0.86	1.25	1.02	7.76	5.62	1.07	0.87	1.27	1.07	8.74	89.09	1.02	0.87	1.26	1.05	88.75
T5	5.33	7.67	9.32	9.39	8.79	0.01	5.50	8.91	10.03	9.57	9.50	0.31	3.13	8.29	9.68	9.48	9.15	1.63
T6	5.63	6.80	9.94	9.61	8.78		5.81	10.33	9.23	9.86	9.81		0.03	8.57	9.59	9.74	9.30	-
C D (p=0.05)	NS	0.99	0.93	0.67	0.86		NS	0.48	0.92	0.77	0.72		NS	0.71	0.89	0.68	0.76	
S E	-	0.33	0.30	0.22	0.28		-	0.17	0.32	0.27	0.25		-	0.27	0.34	0.29	0.30	

BS: before Spray ROC: Reduction over control *Mean population of post treatment periods

Table 3: Insecticidal effect on natural enemies of insect-pests of rice crop yield and cost: benefit

Treatment No.	Mean Spider population per hill days after spray														
	2020					2021					Pooled				
	BS	3	7	10	Mean*	BS	3	7	10	Mean*	BS	3	7	10	Mean*
T1	0.47	0.54	0.58	0.83	0.60	0.45	0.52	0.95	1.31	0.93	0.46	0.53	0.77	1.07	0.79
T2	0.44	0.61	0.58	0.88	0.76	0.42	0.54	0.94	1.29	0.92	0.43	0.58	0.76	1.09	0.81
T3	0.48	0.52	0.67	0.79	0.52	0.46	0.52	0.89	1.36	0.92	0.47	0.52	0.78	1.08	0.79
T3	0.50	0.50	0.50	0.81	0.66	0.48	0.50	1.02	1.28	0.93	0.49	0.50	0.76	1.05	0.77
T5	0.44	0.45	0.45	0.65	0.69	0.42	0.38	0.84	1.33	0.85	0.43	0.42	0.65	0.99	0.69
T6	0.54	0.68	0.69	0.92	0.65	0.52	0.68	0.92	1.17	0.92	0.53	0.68	0.81	1.05	0.85
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

BS: before Spray *Mean population of post treatment periods

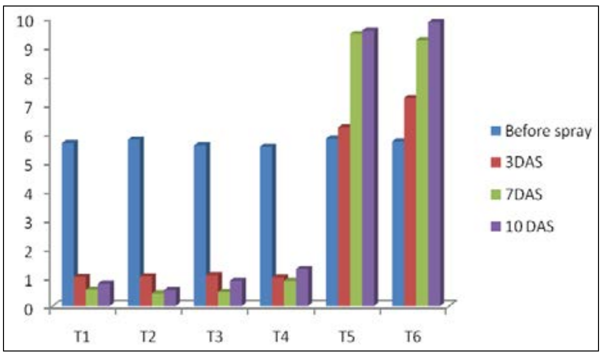

Fig 1: Insecticidal effect on population of plant hoppers (pooled)

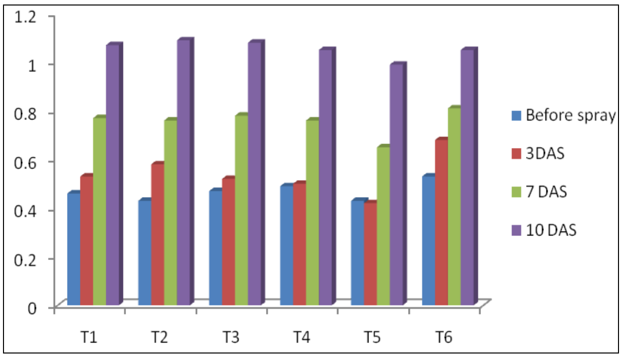

Fig 2: Insecticidal effect on natural enemies' population (pooled)

Table 4: Impact of spray new molecules on grain yield of rice and cost: benefit (Rs.)

Treatment No.	Dose/ha	Yield (q/ha)			Yield increase over control (q/ha)	Income increased over control (Rs.)	Cost of spray (Rs.)	Net profit (Rs.)	Cost : Benefit (Rs.)
		2020	2021	Pooled Mean					
T1	235 ml	72.12(8.55)	76.44(8.80)	74.36(8.68)	8.94	17343.6	3400	13943.60	1: 4
T2	500 g	72.45(8.57)	76.78(8.82)	74.28(8.68)	8.86	17188.4	1554	15634.40	1: 10
T3	300 g	72.19(8.56)	76.52(8.80)	74.61(8.70)	9.19	17828.6	1780	16048.60	1: 9
T3	100 ml	71.74(8.53)	76.03(8.78)	73.89(8.65)	8.47	16431.8	668	15763.80	1: 23
T5	-	66.02(9.19)	69.98(8.43)	65.80(8.22)	0.38	737.2	400	337.20	-
T6	-	63.53(8.03)	67.31(8.26)	65.42(8.15)	0.00	-	Nil.	-	-
CD (p=0.05)		0.15	0.15	0.10	-	-	-	-	-
		0.04	0.05	0.03	-	-	-	-	-

Conclusion
It was concluded that the tested insecticidal molecules against rice plant hoppers (brown plant hopper and white backed plant hopper) of rice proved best in reducing the population from the rice crop field. The tested insecticides resulted in more positive impact on the crop yield, other monetary parameters and resulted in highest amount of additional income. The conservation of natural enemies of insect-pests of rice crop, the tested molecules found relative safer to beneficial insects and spiders that are important in rice ecosystems and can be easily added in rice IPM programs. So, this study can be exploited for against sucking pests of different field fruits and vegetable crops. However, the lowest cost benefit ration was achieved with Pexalon 106 SC @ 235 ml/ha, but farmers are suggested to make alternative spray of insecticidal molecules against plant hoppers to avoid to development of insecticidal resistance and resurgence.

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