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Effect of different granular insecticides on suppression of rice stem borers and plant hopper under rice-wheat cropping system

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Abstract

Field experiments were conducted at three different locations in central Punjab, Pakistan to evaluate the efficacy of different granular insecticides on suppression of rice stem borer (*Scirpophaga incertulas & Scirpophaga innotata*) and plant hopper (*Nilapervata lugens* & *Sogatella forcifera)* for two years (2018 and 2019) during Kharif season. Treatments comprised different granular insecticides; Cartap 4% G, Fipronil 0.3 G, Mover Plus 4.3 % (fipronil 0.3 % + cartap hydrochloride 4%) and Virteko 0.6 GR (chlorantraniliprole 0.2 % + thiamethoxam 0.4 %) @ 22.0, 20.0, 11.0 and 10 kg ha^{-1} respectively. All the insecticides showed varied efficacy against rice stem borer and plant hopper in minimizing the symptoms of dead hearts, white heads and hopper burn. The highest suppression efficacy was recorded with the chlorantraniliprol + thiamethoxam followed by fipronil + cartap hydrochloride against plant hoppers and stem borers. Experimental units treated with chlorantraniliprol + thiamethoxam showed the lowest hopper infestation (9,11 and 8 hoppers per plant) as compared to control where 70, 75 and 68 hoppers per plant was recorded for location I, II and III, respectively. Granular insecticide i.e. chlorantraniliprol + thiamethoxam also reduced the stem borer infestation @ 76, 81 & 78 % at location I, II and III respectively. The experimental unit treated with chlorantraniliprol + thiamethoxam showed a 22% (4266.6 kg ha^{-1}) and 23% (4288.3 kg ha^{-1}) higher paddy yield than control for 2018 and 2019, respectively.

Keywords: dead heart, insecticides, infestation, grain yield,
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Introduction

Rice (*Oryza sativa* L.) is an important cereal crop and it provides food security to a significant proportion of world population. Rice is a major source of food for more than half of the human population. It is also among the primary sources of income and employment for more than 100 million households in Asia. (FAO, 2014). Rice is the third major crop grown in Pakistan after wheat and cotton. In Pakistan, during 2020-21 total area under paddy crop was 3.335 million hectares with 8.419-million-ton production (GOP, 2021). It contributes 3.5% of value addition in Agriculture and 0.7% in national GDP, so it is among the most preferred crops of Pakistan. Fine rice varieties of Pakistan, particularly basmati varieties are very famous around the world owing to their specific aroma. Due to this uniqueness, rice is an export commodity of Pakistan and has gained a status of second most important cereal crop after wheat.

The productivity of rice is declining due to various biotic and abiotic factors. Yarasi et al. (2008), reported that about 52 % of rice production is lost due to damage caused by biotic stresses. Insect pest infestation is also an important factor among other constraints for low average harvest per unit area. Among the biotic stresses, 21% is attributed to the attack of insect pest. In rice-wheat cropping system of Pakistan, insects are the major biotic factors that can cause significant yield reduction in rice. Plant hoppers and yellow stem borers are becoming major pest of rice in rice-wheat cropping system and can cause yield losses to the rice crop at the later stages of crop cycle (Yadav et al., 2019).

Plant hopper especially brown plant hopper (BPH) & white backed plant hopper (WBPH) attacks the crop at late vegetative stage to grain formation stage. Both the adult and nymph of plant hopper suck sap from the plant resulting in chlorosis, wilting and drying up of rice plant. This feeding damage is commonly known as hopper burn. It begins in patches but spread rapidly as the hoppers move from infested plants to adjacent plants and can cause 10-90% yield losses depending upon the intensity of attack. Farmers rely heavily on insecticides for insect pest management in rice and almost 50 % of the insecticides used in rice are targeted against this pest alone (Reddy et al., 2012). Similarly, stem borers are generally considered the most serious pests in rice crop and can reduce the yield by producing dead hearts and white heads at vegetative and earing stages respectively of the plant growth (Mehmood-ur-Rehman et al., 2007).

It becomes compulsory to apply appropriate insecticide, when the pest population reaches to its economic threshold level. Because, the damage at this point is a serious setback to the crop yield and can only be minimized by the application of appropriate pesticide. However, haphazard application of insecticides also creates undesirable effects including environmental pollution, resistance development in target pest, resurgence of the pest and accumulation of residues in the harvested produce. In order to address these complexities, new chemicals are introduced in market every year that could serve all these purposes in a relatively efficient manner, specially the granular pesticides. During the booting stage of rice, plant densities are generally high and most of the farmers are used to apply insecticides as foliar spray, that does not give desirable results due to habituation of pest at the base of stem. These practices reduce the crop yield on account of poor pest management along with detrimental effects on human health. So, judicious use of

insecticides and development of new chemistries are highly required to overcome these problem. A detailed review of literature has shown that several insecticides in different formulations specifically chlorantraniliprol containing granular insecticides are highly effective against stem borers and plant hoppers (Sahu et al., 2020). Moreover, virteko (chlorantraniliprole 0.2 % + thiamethoxam 0.4 %) also proved to be a promising option for managing stem borers, leaf folder and plant hopper (Murali Baskaran et al., 2013). Similarly, Mishra et al. (2012) reported about fipronil as an effective insecticide against stem borers. So the use of new chemistries with systemic mode of actions against the pest can play a vital role in the managing all these pests as well as can also overcome the insecticides resistance problem. Moreover, granular insecticides are also known for their lower toxicity against beneficial fauna (Sanchez-verdejo, et al., 2008) hence can increase yield of rice significantly (Khan et al., 2010).

The present study is focused on evaluation of newly introduced granular insecticides for managing the stem borer and plant hopper in paddy crop in rice wheat cropping system of Punjab, Pakistan.

Materials and Methods

The study was carried out at 3 locations during Kharif 2018 and 2019 under Adaptive Research Zone Sheikhupura, Punjab-Pakistan. The latitude and longitude details of all experimental locations is as following;

Location 1	Adaptive Research Farm, Sheikhupura (N31º 42'36.57" & E73º 45' 45.00")
Location 2	village Naiwala, Markaz Morkhunda, Tehsil & District Nankana Sahib (N 31º 19' 37.70" & E 73º 45' 54.00").
Location 3	Feroz Wattun, Tehsil and District, Sheikhupura (N31º 35' 11.54" & E 73º 46' 29.40" E)

The field was prepared by puddling the soil and 30-day old paddy nursery of cultivar super basmati was transplanted during 1st week of July at all three locations during both years. A square plant geometry with 22.5 cm × 22.5 cm plant to plant and row to row distance was maintained in all the experimental units for achieving a uniform plant population. The fertilizers (NPK) were applied to each experimental unit at departmental recommends rates. The experiment comprised five treatments including control and 4 insecticides including cartap hydrochloride @ 22 kg ha^{-1}, fipronil @ 20.0 kg ha^{-1}, fipronil + cartap hydrochloride @ 11.0 kg ha^{-1} and chlorantraniliprol + thiamethoxam @ 10.0 kg ha^{-1} All the treatments were applied twice with recommended dose. The 1st application was made 55 days after transplanting the paddy crop and the 2nd application was made a week after the panicle initiation in standing water conditions to achieve uniform application of the chemical. Moreover, the experimental units were separated by wide ridges (0.5 wide and 0.25 m high) to avoid transportation of chemical to adjacent experimental units. All the phosphorus (Diamonium Phosphate) was applied to the crop before transplanting. Nitrogen and potassium (Sulfate of Potash) were applied in 2 equal doses. The 1st half dose of potash was applied before transplanting along with phosphorus and 2nd dose of potash was applied at booting stage. Whereas, nitrogen was applied in 2 equal doses at 25 and 50 days after transplanting the paddy crop.

A regular monitoring of field was carried out for observing the infestation of plant hoppers and stem borers attack. For stem borer, dead hearts at vegetative stage and white

heads at reproductive stage were recorded from each experimental unit, whereas for plant hopper, population per plant was recorded from ten randomly selected plants at 3 different experimental locations from each experimental unit during both the years. Population of plant hopper per plant and stem borers infestation was computed with the help of following equations and percent reduction over control was also calculated.

$$\text{No. of Plant Hoppers per plant} = \frac{\text{Total number of adult \& nymph}}{\text{Total number of plants per 10 hills}}$$

$$\text{Stem Borer infestation (\%)} = \frac{\text{Number of dead hearts/white heads}}{\text{Total number of tillers assesed}} X\ 100$$

For estimating the paddy yield, each experimental unit was harvested, threshed and weighed separately and then the grain yield was converted to kg ha^{-1}. The recorded data were subjected to analysis of variance and the means were compared by the least Significant difference test (LSD) at 5% level of significance (Steel & Torrie, 1980).

Results and discussions

Results revealed that all the applied insecticides were effective against stem borers and plant hopper with significant difference. During both the years, all the insecticides remained statistically at par and it was observed that application of insecticides significantly lowered the percentage of dead hearts/white heads and plant hoppers per plant as compared to control (Table 1 and Table 2).

The data on plant hopper population before and after application of granular insecticides presented in Table-I and regarding stem borer's infestation in terms of percent dead hearts and white heads was recorded and presented in Table 2. On average of both crop seasons, the highest (76.2, 82 & 78.6) and (84, 85.5 & 86.6) percent decrease over control of stem borers and plant hopper was recorded from the experimental units treated with chlorantraniliprol + thiamethoxam followed by fipronil + cartap hydrochloride treated plot at three locations (Fig-I and Fig-II). Maximum (70.8, 76.1 & 68.4 plant hoppers per plant) was recorded from control treatment at three locations on average of both crop season 2018 and 2019 while minimum 10-13 hoppers per plant was recorded from the experimental units treated with chlorantraniliprol + thiamethoxam and fipronil + cartap during year 2018 at three locations and a similar trend was observed during 2019. (Table 1).

Data regarding stem borer infestation showed that, maximum percentage of dead hearts (7.2, 8.1 & 7.3) and white heads (10.3, 10.7 & 8.5) was recorded from control plots at all locations during two consecutive crop seasons (Table 2) while minimum 2.33, 2.43 & 2.23 and 2.96 , 2.0 & 1.80 dead hearts and white heads respectively was observed from chlorantraniliprol + thiamethoxam treated plot during crop season 2018 and similar results were observed during crop season 2019 at all the locations under study. Granular insecticide *i.e.* fipronil + cartap remained 2nd in efficacy during both study years at all three locations. (Table 2).

Table 1. Impact of granular insecticides on plant hopper population (per plant) at three locations during Kharif-2018 and 2019.

Treatments	Location-I				Location-II				Location-III			
	2018		**2019**		**2018**		**2019**		**2018**		**2019**	
	B*	A**	B	A	B	A	B	A	B	A	B	A
Cartap Hydrochloride@ 22 kg ha^{-1}	50.33a⌋	21.00b	40.66b	26.33b	60.00a	22.33b	50.66 b	27.00b	62.00b	22.00b	42.66b	22.3 b
Fipronil @ 20.0 kg ha^{-1}	51.66a	15.66c	44.00b	21.00b	62.00a	16.33bc	56.66ab	22.00b	68.33ab	15.67c	42.00b	16.3 bc
Fipronil + Cartap hydrochloride@ 11.0 kg ha^{-1}	53.66a	13.67cd	44.00b	13.67 c	60.33a	13.00c	56.33ab	12.67c	73.67a	13.33c	47.00ab	14.3 cd
Chlorantraniliprol + Thiamethoxam@ 10.0 kg ha^{-1}	56.67a	10.00d	52.00 a	12.00 c	67.33a	11.00c	62.67 a	11.00c	73.00a	9.33 d	50.67a	8.67 d
Control (No chemical application)	56.33a	71.67a	49.33 a	70.00 a	68.67a	78.66a	62.67 a	73.67a	71.33a	77.33a	45.00ab	59.67 a
LSD ($p \leq 0.05$)	**3.88**	**1.66**	**1.65**	**2.46**	**4.73**	**3.23**	**2.79**	**2.94**	**3.62**	**1.21**	**3.40**	**2.65**

*= Before application of insecticide, **= After application of insecticide, ⌋= Means not sharing a letter within a column differed from each other at p **≤0.05.**

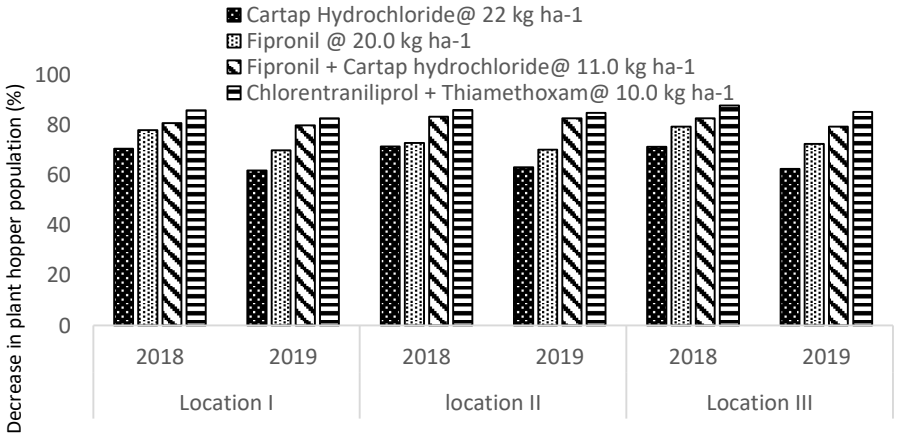

Figure 1. Decrease (%) over control of plant hoppers with the application of different insecticides at three locations during Kharif-2018 and 2019.

Table 2. Comparative Efficacy of different Granular insecticides against stem borers at three locations during Kharif-2018 & 2019.

Treatments	Location-I				Location-II				Location-III			
	2018		**2019**		**2018**		**2019**		**2018**		**2019**	
	DH*	WH**	DH	WH	DH	WH	DH	WH	DH	WH	DH	WH
Cartap Hydrochloride@ 22 kg ha^{-1}	4.10 bJ	4.13 b	3.56 b	3.40 b	4.40 b	3.90 b	3.73 b	3.26 b	4.66 b	3.73 b	2.93 b	3.20 b
Fipronil @ 20.0 kg ha^{-1}	3.56 b	3.96 b	2.96 bc	2.70 bc	3.80 b	3.46 bc	3.06 bc	3.13 b	3.63 c	3.03 b	2.40 b	3.03 b
Fipronil + Cartap hydrochloride@ 11.0 kg ha^{-1}	2.70 c	3.70 b	1.80 c	2.00 c	2.76 c	2.50 cd	2.20 bc	2.66 b	2.83 cd	1.80 c	2.03 b	2.30 bc
Chlorentraniliprol + Thiamethoxam @ 10.0 kg ha^{-1}	2.33 c	2.96 b	1.80 c	2.00 C	2.43 c	2.00 d	1.80 c	1.86 b	2.23 d	1.80 c	1.66 b	1.80 c
Control (No chemical application)	7.00 a	11.30 a	7.53 a	9.36 a	9.00 a	10.83 a	7.33 a	10.60 a	6.56 a	8.43 a	8.03 a	8.43 a
LSD (p≤0.05)	**0.35**	**0.77**	**0.54**	**0.59**	**0.27**	**0.55**	**0.69**	**0.77**	**0.35**	**0.38**	**0.83**	**0.51**

*= Dead hearts, **= White heads, J= Means not sharing a letter within a column differ from each other at p **≤0.05.**

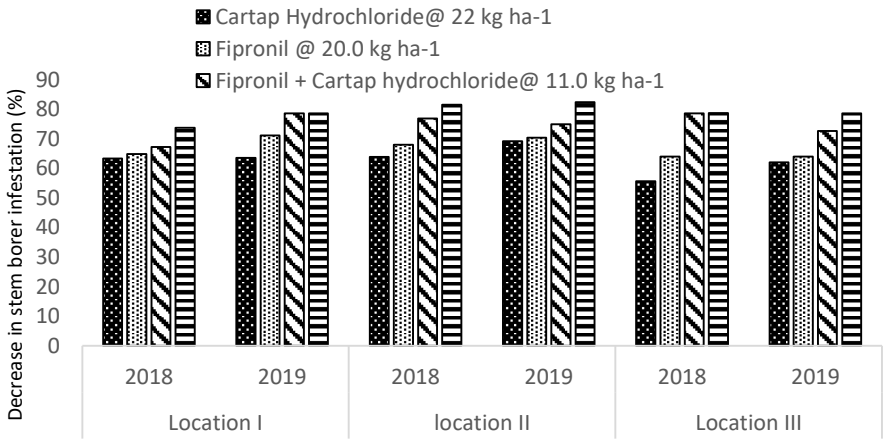

Figure 2. Decrease (%) in stem borer infestation with the application of different insecticides during Kharif-2018 and 2019 at 3 different locations.

These findings are in coherence with the results of Sarao and Kaur, (2014) who reported that new insecticide chlorantraniliprol was very effective in controlling stem borer and it also minimized the population of plant hopper. Our results are in line with those of Naik and Semi (2017), who reported that chlorantraniliprol was better in controlling rice pest. Singh et al. (2015) also reported that chlorantraniliprol and fipronil are a better option in reducing plant hopper and rice stem borers in paddy crop.

Application of granular insecticides for the management of stem borers and plant hopper was elaborated by different researchers like Satyanarayana et al. (2014) found that fipronil was effective in managing stem borers and it also lower hopper infestation. Another interesting observation regarding beneficial insect was also made that granular insecticides broadcasted in standing water did not affect the population of beneficial insects specially of spiders. Data regarding paddy yield presented in Table 3 depicts that chlorantraniliprol + thiamethoxam insecticide helped in achieving highest paddy yield 4166.0, 4258.3 and 4408.3 kg ha^{-1} which is 18.4, 18.3 & 23 % more grains yield as compared to control (Fig-III), during both crop season at all locations, it was followed by the application of fipronil+cartap. Minimum 3478.3, 3483.4 & 3483.3 kg ha^{-1} paddy yield was recorded from control plot at all the locations during both crop seasons *i.e.* 2018 and 2019 (Table 3). These findings are in accordance with the findings of Singh, (2017) who reported that chlorantraniliprol treated plots gave better paddy yield over control. Similarly, Bhutto and Soomro, (2009) also reported that application of granular insecticide increase paddy yield due to its broad spectrum and high insecticidal activity to keep the plant hopper and stem borer under economic threshold level.

Table 3. Impact of granular insecticides on paddy yield and percent increase in yield over control at three locations during the years 2018 & 2019

Treatments	Location-I		Location-II		Location-III	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**
Cartap Hydrochloride@ 22 kg ha^{-1}	3766.7c⌋	3650.0c	3950.0c	3783.3c	3776.7d	3883.3b
Fipronil @ 20.0 kg ha^{-1}	3900.7 b	3800.0 b	4133.3 b	3893.3 c	3950.0 c	3983.3 b
Fipronil + Cartap hydrochloride@ 11.0 kg ha^{-1}	4133.3 a	4106.7 a	4216.7 ab	4033.3 b	4150.0 b	4416.7 a
Chlorentraniliprol + Thiamethoxam@ 10.0 kg ha^{-1}	4150.0 a	4183.3 a	4350.0 a	4166.7 a	4300.0 a	4516.7 a
Control (No chemical application)	3506.7 d	3450.0 d	3500.0 d	3466.7 d	3416.7 e	3550.0 c
LSD 5%	**47.21**	**56.43**	**69.12**	**50.06**	**55.88**	**80.96**

⌋= Means not sharing a letter within a column differ from each other at p **≤0.05.**

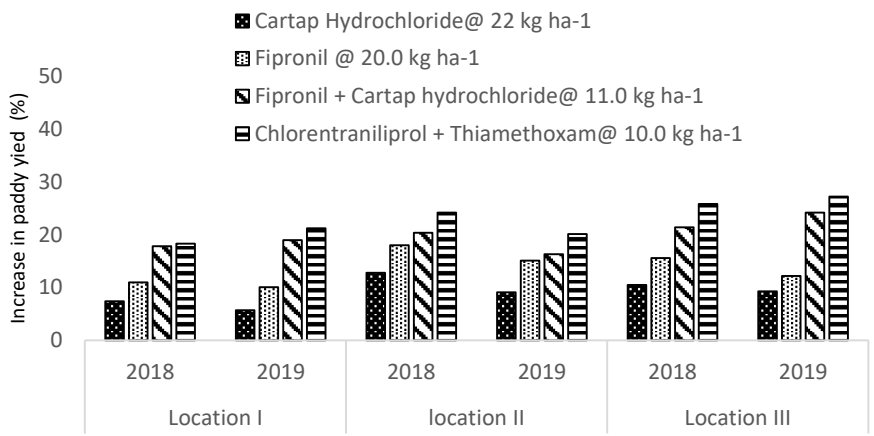

Figure 3. Increase (%) in paddy yield with the application of different insecticides during Kharif-2018 and 2019 at 3 locations.

Conclusion

In conclusion, all the insecticides effectively controlled the rice pest *i.e.* stem borers and plant hoppers that resulted in higher grain yield as compared to the control. However, the application of chlorantraniliprol + thiamethoxam showed highest efficiency in controlling plant hopper and stem borer of rice. It was followed by fipronil + cartap. So, for achieving the optimum control of plant hopper and stem borers in rice crop under rice wheat cropping system of Punjab, Pakistan, chlorantraniliprol + thiamethoxam could be considered as the most viable option.

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