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Trichogramma chilonis, an effective egg parasitoid for control of white stem borer *Scirpophaga innotata* (Walker), (Lepidoptera: Pyralidae) in rice

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Abstract

Rice an important staple food crop of the world, which is attacked by the various insect pests, among them the stem borers are the most destructive pests, distributed in all rice growing areas of the world and cause the severe losses. This research investigated the efficacy of the parasitoid *Trichogramma chilonis* (Ishii) to control the white stem borer (*Scirpophaga innotata*) in rice. In this respect the field studies were conducted in lower Sindh, Pakistan for the year, Kharif - 2017 and 2018. *Trichogramma* egg parasitoid over 230 species are reported to have been remained in biological control of insect pests of over 200 insect species belonging to 70 different families, mainly the order Lepidoptera, Hemiptera, Orthroptera and Thysnoptera, in order to manage the white stem borer of rice the *Trichogramma chilonis* (Ishii) was used as a bio-control agent. The Studies revealed that *T. chilonis* proved an effective biocontrol strategy against white stem borer of rice. The result of this study could be useful in an integrated pest management program for the management of white stem borer of rice the *Trichogramma chilonis.*

Key words: Stem borer, Biocontrol, Parasitoid, Population suppression.

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1. INTRODUCTION

Rice (Oryza sativa L) is a major staple food crop of the world[1]. Next to wheat more than 2 billion people in Asia depend upon rice[2] with 90% produced and consumed in Asia with the final 10% in other continents[3,4]. Rice (Oryza sativa). L, belongs to the family Graminnae is cultivated worldwide, Rice provides one fifth of the calories consumed by human being throughout world[5]. There are two cultivated species of rice: (Oryza sativa), the Asian rice and Oryza glaberrima (African rice) Graminae: Oryza sativa has originated in Asia from crosses between wild ancestors, it became an important crop in China about 3000 BC [6,7]. It is the most widely consumed staple food for a large part of the world's human population. It is Asia's staple food for 50% of the population, with 75% food security of Asia depend upon irrigated rice[8]. After sugar cane (1.9 billion), maize (1.0 billion) and rice is the 3rd crop with higher production 741.5 metric tons[2]. In the year 2009, the world paddy consumption was 531.6 million metric ton, China and India being the first and second largest consumers at 156.3 and 123.5 M tons, respectively, equivalent to 29.4% and 23.3% of the world consumption respectively [9].

Rice is an important Kharif crop of Pakistan next to wheat in respect to cultivation and consumption, both largest food crops wheat and rice contribute 3.1% and 1.4% to GDP, respectively. [10,11] Investigated that stem borers cause heavy damage to rice crop in Pakistan. Among the stem borers, the yellow stem borer (*Scirpophaga incertulas* walker) (Lepidoptera: Pyralidae), white stem borer (*Scripophaga innotata* (Walker)), Pink stem borer (*Sesamia inferens* (Walker) (Lepidoptera: Noctuidae)) and stripped borer (*chilo supressalis* walker) (Lepidoptera: Crambidae) are the most destructive pests of paddy fields[12-16]. To control stem borers, growers use insecticides, but indiscriminate use has lead[17] which has not only polluted the environment, but cause human health effects[18], food contamination[19,20], non-target impacts to wildlife and beneficial arthropod species[21-23].

Therefore, it is essential to use alternative management options, with biological control view by scientists as a way of controlling pest. Trichogrammatids are the minute wasps, among the *Trichogramma* in Pakistan, *T. chilonis* (Ishii) is the most common and dominant over other species many studies have shown that *Trichogramma* can successfully control lepidopteran pests[24-26]. This contribution investigated the effectiveness of *Trichogramma chilonis* (Ishii) to suppress *S. innotata* in a rice crop in the Badin District found within the Sindh province of Pakistan.

2. MATERIALS AND METHODS

2.1 Studied Area

The rice trial site covered 50 Square meters land was prepared at Badin including all the agronomical practices. The nursery was sown in June (spring) and transplanted in July 2017 and again in 2018 respectively at same location. The field was divided into two blocks (replications) A and B, A for *Trichogramma* release and B for control and 50-meter space between treated and untreated plots and A plot was divided in to two replications, no insecticide was used throughout crop season.

2.2 Releases of parasitoids

Trichogramma cards, holding *T. chilonis* eggs were received from the Entomology Section Agriculture Research Institute (ARI), Tandojam and Each card contained 1000 eggs, with cards positioned at 25 locations over the 1/5 of ha (125000/ ha), 30 days after transplanting (first August 2017 and 2018) cards were placed on a 1.0 m pole and protected from rain and sun by a protective shield. Under the temperatures experienced in the field, *T. chilonis* adults emerged on average within one or two days depending upon temperature. Thereafter, 25 cards were released at 15 days intervals after 30 days of transplanting (DAT) and this practice remained continue for the three months August, September and October (spring to autumn).

2.3 Damage assessments

Observations for damage commenced 15 days after the first releases *T. chilonis*, ten hills per treatment were randomly selected and the total number of tillers and infested tillers were recorded and damage infestation percentage and dead heart (where larva mines the central shoot leading to premature tiller death) and white ear head (where the panicle of mature plants is dried, grains are absent, and the plant can be easily pulled

out by hand) were counted and percent reduction in dead heart and white ear head calculated as follows. Analysis was carried out on results from the 30, 60 and 90 DAT.

$$\text{Percent Reduction} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \text{ x } 100$$

The % dead heart (DH %) and white ear head (WEH %) were calculated as follows:

$$\text{Percent dead heart} = \frac{\text{Number of dead hearts}}{\text{Number of total tillers}} \text{ x } 100$$

$$\text{Percent White ear head} = \frac{\text{Number of white hearts}}{\text{Number of total tillers}} \text{ x } 100$$

3. RESULTS AND DISCUSSIONS

3.1 Impact of Trichogramma chilonis on damage % and yield of rice crop for the year 2017 and 2018

The data presented in Table 01 and Fig 01 for the year 2017, show that all the treatments are found significantly superior over control in relation to percent dead heart infestation caused by white stem borer at 30 days after transplanting which varied from 13.2 to 23.2%, being minimum and maximum in treatment of crop with *Trichogramma* with respect to control with reduction in dead heart infestation to the order of 43.1 over the control.

Table 1. Impact of T. chilonis release on damage % of (*Scircophaga innotata*) and yield of rice crop (IRRI-6) -2017.

Treatment	D.H %	DH %	Mean	WH %	Yield kg/ha
	30 DAT	**60 DAT**		**90 DAT**	
T. Chilonis	13.2	10.2	11.7	8.6	6718.4
Control	23.2	25	24.1	26.5	5631.6

While on other hand the (Table 1-2) same for the year 2017, shows that all the treatments were found significantly superior over control in relation to percent dead heart infestation caused by white stem borer of rice at 60 days after transplanting which varied from 10.2 to 25 being minimum and maximum in treatment of crop with *T. chilons* with respect to control with reduction in dead heart infestation to the tune of 59.0 over control. While the same table further shows that all the treatments are found significantly superior over control in relation to percent while ear head infestation caused by white stem borer of rice at 90 days after transplanting which varied from 8.6 to 26.5 being minimum and maximum in treatment of crop with *T. Chilons* with respect to control with reduction in white ear head infestation to the tune of 55.1 over control.

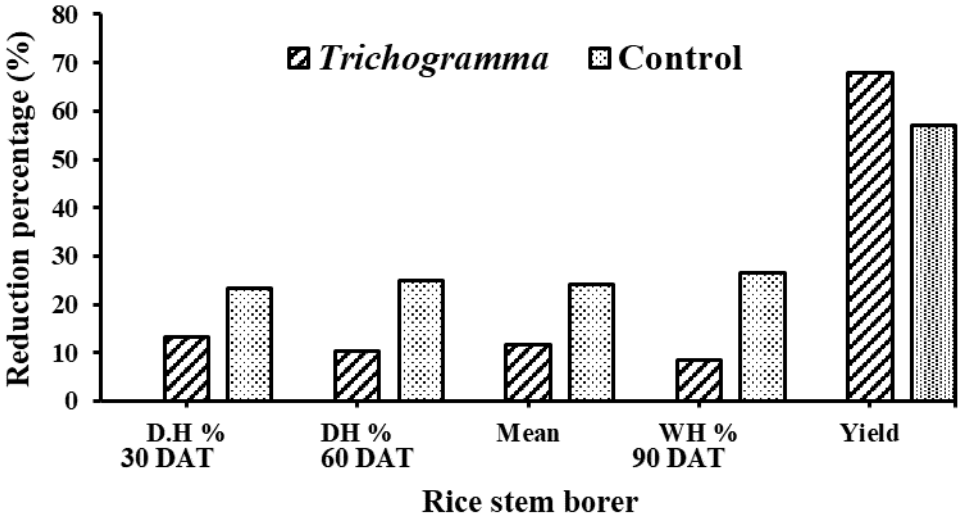

Fig. 1. Impact of *T. chilonis* release 30, 60 and 90 days after transplanting (DAT) on damage to heads (%DH) and (%WH) % (*Scircophaga innotata*) & yield (kg Dry matter/ha) of rice crop (IRRI-6) -2017.

Table 2. Impact of *T. chilonis* release on reduction in pest infestation (*Scircophaga innotata*) and yield of rice crop. (IRRI-6)- 2017.

Treatment	% Reduction in dead heart over control			% Reduction in white Ear head over control	% Increase in yield over control
	30 DAT	**60 DAT**	**Mean**	**90 DAT**	
T. Chilonis	43.1	59	51.2	55.1	19.2

Table 3. Cost / benefit ratio calculated *T. chilonis* for management of white stem borer (*Scircophaga innotata*) on rice crop -2017.

Treatment	Dose	Additional yield over control kg./ha	Price of additional yield over control Rs./ha	Cost of treatment over control Rs /ha	Net profit/loss over control Rs/ha	ICBR
T. Chilonis	**25 cards**	**1086.8**	**35321**	**2500**	**32821**	**01:14.12**

3.2 Impact of Trichogramma chilonis on damage% and yield of rice crop for 2018

In 2018 all treatments are found significantly superior over control in relation to percent dead heart infestation caused by white stem borer of rice at 30 days after transplanting (Table 04, Fig 02). The % reduction ranged from 14.9 to 21.5 in treatment of crop with *T. chilonis* with respect to control and treatment observed (Table 5) of the crop with *trichogramma* with reduction in dead heart infestation to the tune of 34.7 over control. The table further shows that all the treatment were found significantly superior over control in relation to percent dead heart infestation caused by white stem borer of rice at 30 days after transplanting for the year 2018 which varied from 14.09 to 21.5, being minimum and maximum in treatment of crop with *Trichogramma* with respect to control with reduction in dead heart infestation to the tune of 34.7 over control. Table 4 shows that all treatments were found significantly superior over control in relation

to percent dead heart infestation caused by white stem borer of rice at 60 days of transplanting which varied from 10.7 to 21.6 being minimum and maximum in treatment of crop with *T. chilions* with reduction in dead heart infestation to 50.2% over the control.

Table 4. Impact of *T. chilonis* release on damage % of *(Scircophaga innotata)* & yield of rice crop (IRRI-6) - 2018.

Treatments	D.H %	DH %	Mean	WH %	Yield kg/ha
	30 DAT	**60 DAT**		**90 DAT**	
T. Chilonis	14.9	10.7	12.4	11.7	6916
Control	21.5	21.6	21.6	21.4	5730.4

The data further demonstrate that all the treatment were found significantly superior over control in relation to white ear head infestation caused by white stem borer of rice at 90 days after transplanting which varied from 12.4 to 21.6 being minimum and maximum in treatment of crop with *Trichogramma* with respect to control with reduction in white ear head infestation to the tune of 45.1 over control.

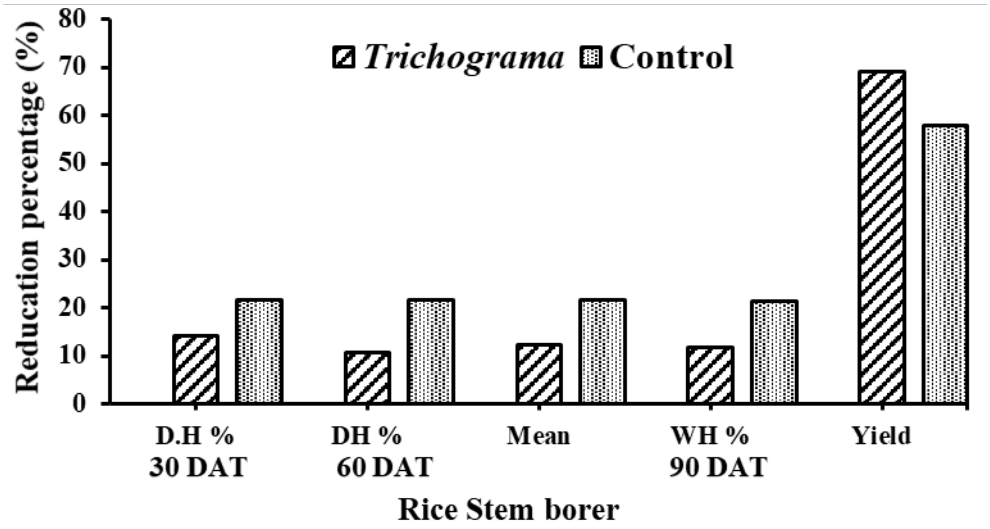

Fig. 3. Impact of *T. chilonis* release on reduction in pest infestation *(Scircophaga innotata)* & yield of rice crop (IRRI-6) - 2018.

Table. 5. Impact of *T. chilonis* release on reduction in pest infestation by (*Scircophaga innotata*) and yield of rice crop (IRRI-6) – 2018.

Treatment	Percent reduction in dead heart over control		Percent reduction in white ear head over control		Percent increase in yield over control
	30 DAT	**60 DAT**	**Mean**	**90 DAT**	
T. Chilonis	34.7	50.2	42.4	45.1	18.1

Table 6. Cost/benefit ratio calculated for *T. chilonis* for management of white stem borer (*Scircophaga innotata*) on rice crop -2018.

Treatment	Dose	Additional yield over control kg/ha	Price of additional yield over control Rs./ha	Cost of treatment over control Rs/ha	Net profit/ loss over control Rs /ha	ICBR
T. Chilonis	25 cards	1185.6	38532	2500	36032	01:15.41

3.2 Impact of Trichogramma chilonis on damage % and yield of rice crop for 2017 and 2018

The Table 07 and Fig 03 pooled mean for the year 2017 and 2018, reveals that all the treatment were found significantly superior over control in relation to percent dead heart infestation caused by white stem borer of rice at 30 days after transplanting which varied from 13.6 to 22.4, being minimum and maximum in treatment of crop with *Trichogramma* with respect to control and infestation to the tune of 39.0 over control.

Table 7. Impact of *T. chilonis* release on reduction in pest infestation (*Scircophaga innotata*) and yield of rice crop (IRRI-6) - (Pooled Mean 2017-2018).

Treatments	Dead heart %			White Ear head %	Yield kg/ha
	30 DAT	**60 DAT**	**Mean**	**90 DAT**	
T. Chilonis	13.6	10.5	12.08	10.1	6718.4
Control	22.4	23.3	22.8	23.9	5730.4

The table 7 also shows that all the treatment was found significantly superior over control in relation to percent dead heart infestation caused by white stem borer of rice at 60 days of transplanting which varied from 10.5 to 23.3 being minimum and maximum in treatment of crop with *Trichogramma* with respect to control with reduction in dead heart infestation to the tune of 39.0 over control. Furthermore, the data reveals that all the treatment were found significantly superior over control in relation to percent white ear head infestation caused by white stem borer of rice at 90 days after transplanting which varied from 10.1 to 23.9 being minimum and maximum in treatment of crop with *Trichogramma* with respect to control with reduction in white ear head infestation to the tune of 57.5 over control (Table 8). Cost benefit ratio calculated *Trichogramma* for management of white stem borer for the year 2017 and 2018.

The table 03 reveals that grass expenditure/ cost to be incurred on various applications of *Trichogramma* for the year 2017 was Rs: 2500 and additional yield over control was 1086.8 kg/ha and the price of yield over control was Rs: 35321 and net profit over control was Rs: 32821 and cost benefit ratio was 1:14.12. While the table 06 points out that grass expenditure/cost to be incurred on various applications of *Trichogramma* for the year 2018 was Rs: 2500 and additional yield over control was 11085.6 kg/ha and price of additional yield over control was Rs: 38532 and net profit over control was Rs: 36032 and cost benefit ratio was 1:15.41. While the table 09 reveals that grass expenditure/cost to be incurred on various applications of *Trichogramma*, pooled mean for the year Kharif 2017 and 2018 was Rs: 2500 and additional yield over control was 1136 kg/ha and price of additional yield over control was Rs: 36926 and net profit over control was Rs: 34426 and Cost benefit ratio was 1:14.77.

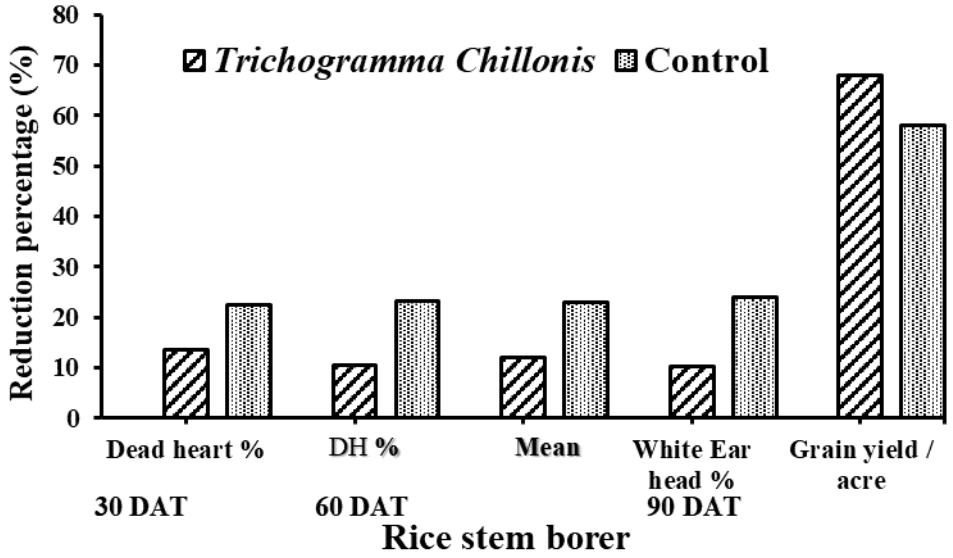

Fig. 3. Overall Impact of *T. chilonis* release on damage of white stem borer *(Scircophaga innotata) and* yield of rice crop (pooled mean) - 2017 & 2018.

Table 8. Impact of *T. chilonis* release on reduction in pest infestation (*Scircophaga innotata*) & yield of rice crop (IRRI-6) - (Pooled Mean 2017-2018).

Treatment	Percent reduction in dead heart over		Percent reduction in white Ear head over		Percent increase in yield over control
	30 DAT	**60 DAT**	**Mean**	**90 DAT**	
T. Chilonis	39.0	54.9	47	57.5	17.24

Table 09. Cost / benefit ratio calculated (*Trichogramma chilonis*) for management of white stem borer (*Scircophaga innotata*) on rice crop (Pooled Mean 2017 & 2018.)

Treatments	Additional yield over control kg/ha	Price of additional yield over control Rs. /ha	Cost of treatment over control Rs/ha	Net profit / loss over control Rs/ha	ICBR
T. Chilonis	1136	36926	2500	34426	01:14.77

Chemical pesticides have been used for long time due to its quick action. However, excess use of pesticides significantly damages to environment and non-target on beneficial insect and mammals[21, 27, 28]. In our experiment, we employed *T. chilonis* against white stem borer in rice. The results are in agreement with the studies of [23] achieved the most efficient control measure against stem borers of rice and reduced infestation by (84.8%) at panicle stage and (79.3%) at heading stage when *T. evanescens* (west wood), was released at panicle initiation stage and at all crop growth stages. Yellow stem borer of rice was parasitized by *T.japonica* 7-14% [29]. Study [30] reported (12-32%) egg parasitism of white stem borer of rice in Egypt during 2015-2016. In Egypt [31] found 70% control of rice stem borer *C.agamemnon*, while *T. japonicum* parasitized the eggs of stem borers with reduction (77%) in dead heart and (29%) in White ear head and 11-12% increase in yield. [30] elucidate same results who received 12% increase in rice yield due to release of *T. japonicum*.

Trichogramma have been reported in the field to be very effective bio control agents against rice leaf folder, stripped stem borer and yellow stem borer with parasitism rates of eggs range from 46.7% to 79.1% in the field[31-33]. At least 12 species have been found to be successful in suppressing their host pest [34]. *T. chilonis* adults released at temperatures of 32-40 °C, provided 50% parasitism[35] and found effective against the rice leaf folder (*Cnaphalocrocis medinalis* (Guenée) Lepidoptera: Crambidae)) in rice and reduced stalk borer incidence in sugar cane 55-60% [36]. According to [37] in Brinjal, the release of *T. chilonis* on 30, 60 days after transplant (DAT) resulted least fruit damage and gave superior results to quinalphos with 45.8% larval reduction when used against diamond back moth in cauliflower. In cabbage, the seasonal parasitism recorded 55% on eggs of diamond back moth in India[38]. Although the previous study demonstrates that the borer infestation reduction 25-71% [24, 31] which are in conformity of our findings.

4. CONCLUSIONS

Trichogramma have been used as a natural effective and efficient bio control agent in biological control since long being the egg parasitoids they have been proved a best bio control strategy against insect pests. They can be easily reared and multiplied in the laboratory for mass multiplication, so it is important to aware the farming community regarding the use of such beneficial natural enemy to combat the pest problem to avoid the use of chemicals for sound environment, food and ecosystem.

AUTHORS CONTRIBUTIONS

MYR, AGL and BHC conceived and designed experiment. MYR, AB conducted experiments. MRM, JU DH, and ZL contributed analytical tools and technical assistance. MYR, MRM, BHC, and AR participated the presenting data. MYR, BHC and AGL developed the manuscript, reviewed and made editorial comments on the draft manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Zeigler, Robert S., and Adam Barclay. "The relevance of rice." 2008:3-10. https://doi.10.1007/s12284-008-9001-z
2. FAO STAT. Comparing Data, Region [WWW Document]. 2017 (accessed 2.12.17) http://www.fao.org/faostat/en/#compare
3. Ampong, N. and De Datta, S.K. A handbook for weed control in rice. 1991; International rice research institute
4. Saxena, S. and Murty, N. S. Weather based model development for outbreak of mustard aphid (l. erysimi.,kalt) using artificial neural network. The Ecoscan. 2014;8(1&2):47-52.
5. Muthayya, S., Sugimoto, J.D., Montgomery, S., Maberly, G.F. An overview of global rice production, supply, trade, and consumption. Annals of the new york Academy of Sciences, 2014;1324(1);7-14.
6. Hu, C., Shi, J., Quan, S., Cui, B., Kleessen, S., Nikoloski, Z., Tohge, T., Alexander, D., Guo, L., Lin, H., Wang, J., Cui, X., Rao, J., Luo, Q., Zhao, X., Fernie, A.R., Zhang, D. Metabolic variation between japonica and indica rice cultivars as revealed by non-targeted metabolomics. Scientific reports, 2015;4(1):1-10.
7. Qian, Q., Guo, L., Smith, S.M., Li, J., 2016. Breeding high-yield superior quality hybrid super rice by rational design. National Science Review, 2016;3(3):283-294.

8. Virk, P. S., Khush, G. S., & Peng, S. Breeding to enhance yield potential of rice at IRRI: the ideotype approach. International Rice Research Notes, 2004;29(1):5-9.
9. FAO (FAO STAT). "Food Balance Sheets > Commodity Balances > Crops Primary Equivalent". Retrieved August 17, FAO 2012.
10. Abedullah, Kouser, S. and Mushtaq, K. Analysis of technical efficiency of rice production in 206 Punjab (Pakistan): Implications for future investment strategies. Pakistan Economic and 207 Social Review, 2007;231-244.
11. Memon, N.A (2013) Rice: Important cash crop of Pakistan. Pak. Food J, 2013; 21(2):245
12. Ali, M. P., Bari, M. N., Haque, S. S., et al. Response of a rice insect pest, *Scirpophaga incertulas* (Lepidoptera: Pyralidae) in warmer world. BMC Zoology, 2020; 5(1):1-8. https://doi.org/10.1186/s40850-020-00055-5
13. Chang, B.H., Chang, A.H., Lanjar, A.G., Bukero, A., Nizamani, I.A., Rajput, A., Magsi, F.H., Khan, M., Asghar, F. and Zhang, Z. Insect Biodiversity in Brinjal Agro-Ecosystem. Biological Sciences-PJSIR, 2019;62(3):199-205.
14. Inayatullah, C., Rehman, A. and Ashraf, M. Management of insect pests of paddy in Pakistan. Progressive Farming (Pakistan), 1986;6(1):54-62.
15. Salim, M., A. Rehman and M. Ramzan. Leaf folder (LF) outbreak in Punjab, Pakistan. 251 International Rice Research Newsletter, 1991;(16):22-22.
16. Rehman, A., Inayatullah, C. and Majid, A Descriptive model to predict the outbreaks of yellow rice stem borer, Scirpophaga incertulas. Pakistan Journal of Agricultural Research, 2002;17(3):282-289.
17. Chang, B. H., Lanjar. A. G., A. W, Solangi., et al. Evaluation of different insecticides against sucking insect pest on Sunflower crop at Sindh. European Academic Research, 2016, IV (1):188-206
18. Abro, N.A., Wang G, Ullah H, Long GL, Hao K et al. Influence of Metarhizium anisopliae (IMI330189) and Mad1 protein on enzymatic activities and Toll-related genes of migratory locust. Environmental Science and Pollution Research, 2019;26:17797. https://doi.org/10.1007/s11356-019-05158 -2
19. Hansen, M. (1987). Escape from the pesticide treadmill: Alternatives to pesticides in developing countries (No. 632.95 H35).
20. Waage, J. Making IPM work: developing country experience and prospects. In Agricultural and Environmental Challenges. Proceedings of the Thirteenth Agricultural Sector Symposium Washington, DC: World Bank. 1993;119-33.
21. Chang, B.H., Qiang, B., Li, S., Ullah, H., Hao, K., McNeill, M.R., Rajput, A., Raza, A., Huang, X. and Zhang, Z. Inhibitory effect of genistein and PTP1B on grasshopper *Oedaleus asiaticus* development. Arthropod-plant interactions, 2020;(14):441–452. https://doi.org/10.1007/s11829-020-09757-6
22. Chang, B.H., Cui, B., Ullah, H., Li, S., Hao, K., Tu, X., Wang, G., Nong, X., McNeill, M.R., Huang, X. and Zhang, Z. Role of PTP/PTK trans activated insulin-like signalling pathway in regulation of grasshopper (*Oedaleus asiaticus*) development. Environmental Science and Pollution Research, 2019;26(8):8312-8324. https://doi.org/10.1007/s11356-019-04212-3
23. Udin, A.M., Chang, B.H., Lanjar, A.G., Magsi, F.H., Bukero, A., Nizamani, I.A., Pirzado, V.A. and Zhang, Z. Comparative Efficacy of Leaf Extracts of Different Tobacco Varieties Against Mustard Aphid (*Lipaphis erysimi* Kalt.). Gesunde Pflanzen, 2019;71(4):271-279. https://doi.org/10.1007/s10343-019-00473-7
24. Hendawy, A.S., Sherif, M.R., El-Sayed, A.A. et al. Role of the egg parasitoid, *Trichogramma evanescens* West., release and silica applications in controlling of the stem borer, *Chilo agamemnon* Bles. (Lepidoptera: Crambidae), in rice fields in Egypt. Egypt J Biol Pest Control, 2018;28, 92. https://doi.org/10.1186/s41938-018-0091-7
25. Lou, Y. G., Zhang, G. R., Zhang, W. Q., Hu, Y., & Zhang, J. (2014) Reprint of: Biological control of rice insect pests in China. Biological Control, 2014;9(68):103-116. https://doi.org/10.1016/j.biocontrol.2013.09.018
26. Wang, Z. Y., He, K. L., Zhang, F., Lu, X., & Babendreier, D. Mass rearing and release of *Trichogramma* for biological control of insect pests of corn in China. Biological Control, 2014;(68):136-144.
27. Ghosh, E., Ballal, C. R. Short-term storage of the egg parasitoids, *Trichogramma* and *Trichogrammatoidea*. Egyptian Journal of Biological Pest Control, 2019;28(1):34. https://doi.org/10.1186/s41938-018-0039-y

28. Gupta, S., & Dikshit, A. K. Biopesticides: An ecofriendly approach for pest control. Journal of Biopesticides, 2010;3(Special Issue), 186.
29. Marub, F. YRSB eggs parasitoid potential to different rice varieties in an IPM. Ilum Pertania, 1993;5(3):645-656.
30. Asaady, H. B. and I. N. Navai. Effects of rearing conditions on the efficacy of *Trichogramma* against rice stem borer (*Chilo suppressalis*) and green rice semi-looper (*Naragna aenescens*) in Mazandaran. Trichogramma News, 1995;28:33
31. Sherif MR, Hendawy AS, El-Habashy MM. Utilization of *Trichogramma evanescens* for controlling rice stem borer, Chilo agamemnon Bles. in rice fields in Egypt. Egypt J. Biol. Pest Control, 2008;(18):11–16
32. Guo, H., Fang, J., Xie, Y., & Du, Z. W. Egg parasitism of rice stem borers in regions with different rice stem borer occurring patterns. Chinese Journal of Biological Control, 2002;18(1):13-16.
33. Samara, R. Y., Carlos Monje, J., & Zebitz, C. P. Comparison of different European strains of *Trichogramma aurosum* (Hymenoptera: Trichogrammatidae) using fertility life tables. Biocontrol Science and Technology, 2008;18(1):75-86. https://doi.org/10.1080/09583150701749789
34. Kumar, G. A., Jalali, S. K., Venkatesan, T., Stouthamer, R., Niranjana, P., & Lalitha, Y. Internal transcribed spacer-2 restriction fragment length polymorphism (ITS-2-RFLP) tool to differentiate some exotic and *indigenous trichogrammatid* egg parasitoids in India. Biological control, 2009;49(3), 207-213.
35. Kumar, G. A., Jalali, S. K., Venkatesan, T., Stouthamer, R., Niranjana, P., & Lalitha, Y. Internal transcribed spacer-2 restriction fragment length polymorphism (ITS-2-RFLP) tool to differentiate some exotic and indigenous trichogrammatid egg parasitoids in India. Biological-control,2009;49(3):207-213. https://doi.org/10.1016/j.biocontrol.2009.02.010
36. Sagheer, M., Ashfaq, M., & Rana, S. A. Integration of some biopesticides and *Trichogramma chilonis* for the sustainable management of rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae). Pakistan Journal of Agricultural Sciences (Pakistan), 2008;45(1):69-74
37. Khan, A. A. Exploitation of *Trichogramma chilonis* Ishii for suppression of *Helicoverpa armigera* (Hübner) in tomato. Journal of Insect Science (Ludhiana), 2011; 24(3): 254-258.
38. Shukla, A and Kumar A. Seasonal activity of egg parasitoid, *Trichogramma chilonis* Ishii on diamondback moth, *Plutella xylostella* (Linn.) infesting cabbage (Lepidoptera: Plutellidae). Uttar pradesh journal of zoology, 2004;277-280.