Indian Journal of Agricultural Sciences **87** (10): 1412–5, October 2017/Short Communication
https://doi.org/10.56093/ijas.v87i10.75062

On-farm impact of egg parasitoid, *Trichogramma chilonis* against maize stem borer, *Chilo partellus* in Punjab

P S SHERA[1], SUDHENDU SHARMA[2], JAWALA JINDAL[3], MANINDER BONS[4], GURPARTAP SINGH[5], AMIT KAUL[6], RABINDER KAUR[7] and K S SANGHA[8]

Punjab Agricultural University, Ludhiana, Punjab 141 004

Received: 22 February 2017; Accepted: 29 May 2017

Key words: Augmentative biocontrol, *Chilo partellus*, Maize, *Trichogramma chilonis*

Maize (*Zea mays* L.) is an important cereal crop consumed as food by man and feed by livestock, besides its use in various industrial products. It is cultivated on nearly 185 m ha in about 168 countries having wider diversity of soil, climate, biodiversity and management practices (FAOSTAT 2016). It is the third most important food crop after rice and wheat in India, wherein **o**ver 85% of maize produced in the country is consumed as human food**.** India's maize production for 2016-17 was expected to reach to the tune of 24.5 million tons (USDA-FAS 2016). However, the crop yield in India lags behind leading maize producing countries of the world in terms of productivity. Among the various abiotic and biotic factors affecting productivity, attack of insect pests is important and the economic losses due to these had been reported to be 13.2% (Kumar 2014). Several insect pests cause severe economic losses to food as well as fodder crop of maize. The major insect pests include stem borer, *Chilo partellus* (Swinhoe), shoot flies, *Atherigona naqvii* Steyskal and *Atherigona soccata* Rondani, armyworm *Mythimna separata* (Walker), silk cutter *Helicoverpa armigera* (*Hübner),* hairy caterpillar, *Spilosoma* sp., corn leaf aphid *Rhopalosiphum maidis* (Fitch.) and thrips *Frankliniella* sp. The use of synthetic insecticides is widely adopted for the management of these pests. However, their indiscriminate use has resulted in disturbances of the environment, pest resurgences, resistance to pesticides and effect on non-target organisms (Prakash *et al*. 2008).

Biological control represents an eco-friendly alternative to chemical insecticides for the management of insect pests. In many agro-ecosystems, management of insect pests is carried out by different egg, larval and pupal parasitoids. Egg parasitoids, *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) are being widely used for biological control of Lepidopteran pests (Bueno *et al.* 2010). The studies on these parasitoids had been carried out in more than 50 countries and commercial releases had been successfully performed in about 32.0 million hectares of agricultural fields every year including those in India (Pizzol *et al.* 2010). Egg parasitism by *Trichogramma chilonis* Ishii had been observed to be quite effective in the biological suppression of maize stem borer, *C. partellus* in maize (Jalali and Singh 2003, Farid *et al.* 2007). Punjab Agricultural University, Ludhiana had recommended to the farmers of the state, single release of *T. chilonis* @ 100 000/ha on 10-15 days old crop against maize borer. The present study, was, therefore undertaken at farmers' fields in the main maize growing areas of the state to validate the efficacy of this technology against maize stem borer and to infer economic benefits as means of technology adoption under field conditions.

The large scale demonstrations for the management of maize stem borer, *C. partellus* using *T. chilonis* were conducted at farmers' fields in Hoshiarpur, Shaheed Bhagat Singh Nagar, Roop Nagar, Pathankot and Jalandhar districts of Punjab over an area of 80.8 and 130 ha during 2014 and 2015, respectively. Each field was divided into three blocks representing three treatments, viz. single release of *T. chilonis* @ 100 000 parasitoids per ha, farmers' practice (chemical control) and untreated control. The culture of *T. chilonis* was maintained in the Biological Control Laboratory, Department of Entomology, Punjab Agricultural University (PAU), Ludhiana. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the central whorl leaves on 10-15 days old crop in the biocontrol treatment. In chemical control, deltamethrin 2.8 EC @ 200 ml/ha (recommended by PAU) was sprayed 1-2 times

[1,2,7]Assistant Entomologist (e mail: psshera@pau.edu, sudendhu@pau.edu, rebakaur@pau.edu), [8]Senior Entomologist (e mail: kssangha@pau.edu), Department of Entomology; [3]Assistant Entomologist (e mail: jindal_ento@pau.edu), Department of Plant Breeding and Genetics, PAU, Ludhiana. [4]Assistant Professor (e mail: msbons-hsp@pau.edu), Krishi Vigyan Kendra, Hoshiarpur. [5]District Extension Specialist (e mail: gps@pau.edu), Farm Advisory Services, Hoshiarpur. [6]Assistant Professor (e mail: amitkaul@pau.edu), Krishi Vigyan Kendra, Pathankot.

using 150 litres of water per ha. The larvae of *C. partellus* cause damage by scraping the leaves and then bore into the stem through the whorl or leaf sheath. The growing point is killed resulting in dead heart symptoms. For recording observations, number of infested plants was counted from 100 randomly selected plants at 30 days after germination in each plot. The per cent dead heart incidence due to *C. partellus* was calculated using formula as below.

$$\text{Dead hearts (\%)} = \frac{\text{Infested plants}}{\text{Total number of plants}} \times 100$$

The grain yield at harvest was adjusted to 15% moisture and converted to hectare basis (Bhimsen 1977). The data on per cent dead hearts due to *C. partellus* were subjected to analysis of variance (ANOVA) after arcsine transformation. The different treatment means were separated by least significant difference (LSD) test at 5% probability level (Gomez and Gomez 1984).

The results during 2014 (Table 1) showed significantly lower dead hearts incidence, i.e. 2.70 and 4.40% in farmers' practice and parasitoid released plots, respectively in the field areas at Roop Nagar. Both the treatments were significantly better than untreated control (9.40%). At Hoshiarpur field areas, lowest dead heart incidence (5.33%) was recorded in farmer practiced plots. It was significantly lower than bioagent released plots, wherein the incidence was 6.80%. However, highest dead heart incidence (16.57%) was recorded in untreated control. Based on mean of two locations, farmers' practice was best in reducing the dead heart incidence (4.02%) and was comparable to parasitoid released plots (5.60%). Significantly higher dead heart incidence (12.98%) was recorded in untreated control. The per cent reduction in incidence over control was 56.86 and 69.03 in released and farmers practice, respectively.

Table 1 Effect of *T. chilonis* releases on incidence of *C. partellus* in *Kharif* maize during 2014

Treatment	Dead hearts (%)			Reduction in incidence over control (%)
	Roop Nagar	Hoshiarpur	Mean	
T. chilonis @ 100 000/ ha	4.40[a] (12.05)	6.80[b] (15.08)	5.60[b] (13.56)	56.86
Deltamethrin 2.8 EC @ 200 ml/ ha	2.70[a] (9.42)	5.33[a] (13.31)	4.02[a] (11.36)	69.03
Untreated control	9.40[b] (17.82)	16.57[c] (23.95)	12.98[c] (20.88)	
LSD (P=0.05)	(3.30)	(1.40)	(1.49)	

Means in a column followed by the same letters are not significantly different at P = 0.05. Figures in parentheses represent arc sine transformed values

During 2015 (Table 2), the dead heart incidence in parasitoid released and farmers' practice plots was at par with each other in field areas of Shaheed Bhagat Singh Nagar (4.20 and 2.90%), Pathankot (1.80 and 1.00%) and Jalandhar (4.95 and 3.20%) districts. However, it was significantly lower in farmers' practice (2.00 and 6.54%) than in released plots (3.10 and 7.68%) in Roop Nagar and Hoshiarpur, respectively. Both the treatments were significantly better than untreated control in reducing the stem borer damage (4.10 to 16.54%) at all the locations. Based on mean of all locations, farmers' practice was found to be significantly effective in reducing maize borer incidence (3.13%) than parasitoid released fields (4.35%). Significantly higher dead hearts were recorded in untreated control (9.91%). The mean reduction in incidence over control was 56.10 and 68.42% in parasitoid release and farmers' practice, respectively.

During 2014, the grain yield at both the locations, *i.e.* Roop Nagar and Hoshiarpur in the parasitoid released fields (55.68 and 45.29 q/ha) and farmers practiced plots (58.13 and 47.43 q/ha) was significantly higher than untreated control (50.93 and 37.92 q/ha). The mean yield in both released (50.48 q/ha) and farmers practiced plots (52.78 q/ha) was at par with each other (Table 3). However, untreated control plots recorded significantly lower mean yield (44.42 q/ha). The mean increase in yield over control in released and farmer practice plots was 13.64 and 18.82%, respectively.

The grain yield in bioagent release and farmers' practice fields was at par at Hoshiarpur (45.90 and 48.33 q/ha), Shaheed Bhagat Singh Nagar (50.30 and 53.60 q/ ha), Pathankot (46.67 and 48.40 q/ha) and Jalandhar (53.60 and 56.80 q/ha) during 2015. The yield was significantly higher in farmers' practice (56.40 q/ha) than release fields (52.50 q/ha) at district Roop Nagar (Table 4). However,

Table 2 Effect of *T. chilonis* releases on incidence of *C. partellus* in *Kharif* maize during 2015

Treatment	Dead hearts (%)						Reduction in incidence over control (%)
	Roop Nagar	Hoshiarpur	SBS Nagar	Pathankot	Jalandhar	Mean	
T. chilonis @ 100 000/ ha	3.10[b] (10.09)	7.68[b] (16.06)	4.20[a] (11.79)	1.80[a] (7.59)	4.95[a] (12.83)	4.35[b] (11.67)	56.10
Deltamethrin 2.8 EC @ 200 ml/ha	2.00[a] (7.94)	6.54[a] (14.76)	2.90[a] (9.75)	1.00[a] (5.66)	3.20[a] (10.23)	3.13[a] (9.67)	68.42
Untreated control	7.60[c] (15.96)	16.54[c] (23.97)	9.18[b] (17.60)	4.10[b] (11.57)	12.14[b] (20.35)	9.91[c] (17.89)	
LSD (P=0.05)	(1.97)	(0.49)	(3.01)	(2.08)	(3.26)	(0.80)	

Means in a column followed by the same letters are not significantly different at P = 0.05. Figures in parentheses represent arc sine transformed values

Table 3 Effect of *T. chilonis* releases for the management of *C. partellus* on yield in *Kharif* maize during 2014

Treatment	Yield (q/ha)			Increase in yield over control **(%)**
	Roop Nagar	Hoshiarpur	Mean	
T. chilonis @ 100 000/ ha	55.68[a]	45.29[a]	50.48[a]	13.64
Deltamethrin 2.8 EC @ 200 ml/ ha	58.13[a]	47.43[a]	52.78[a]	18.82
Untreated control	50.93[b]	37.92[b]	44.42[b]	
LSD (P=0.05)	4.35	4.98	2.75	

Means in a column followed by the same letters are not significantly different at P = 0.05.

both the treatments were significantly better in attaining higher yield than untreated control (45.40 q/ha). The mean yield in farmers' practice was significantly higher (52.71 q/ha) than release fields (49.79 q/ha), which in turn was significantly better than untreated control (42.57 q/ha). The mean increase in yield over control in farmers' practice and bioagent released plots was 23.82 and 16.96%, respectively.

The cost benefit analysis during 2014 revealed additional yields of 6.06 and 8.36 q/ha in *Trichogramma* released and farmers' practice treatments, respectively. The net returns were higher (₹ 10592/ha) in farmer practice as compared to ₹ 7734/ha in parasitoid released released plots. However, the cost:benefit ratio in the parasitoid released plots (1: 37.72) was higher than in farmers' practice plots (1: 29.42). During 2015 also, higher net returns were recorded in farmers' practice (₹ 11751/ha) than in release plots (₹ 9362/ ha). The cost: benefit ratio was again comparatively higher in parasitoid released plots (1:45.67) as against farmers' practice (1:32.64) plots (Table 5).

From the present study, it was conclusively proved that maize borer, *C. partellus* can be managed successfully and yield can be increased through augmentative release of *T. chilonis* @ 100 000 per ha on 10-15 days old maize crop. The efforts to avoid these crop losses due to insect pests have predominantly relied on the use of chemical insecticides. However, indiscriminate use of synthetic insecticides not only increases the cost of production but also has led to many ecological backlashes like resistance to insecticides, residues, pest resurgence, environmental toxicity, ground water and surface water contamination, food safety hazards and human health concerns, etc (Singh 2012). In this context, biocontrol practice through use of *Trichogramma* spp. not only reduced the pest infestation in maize but also yielded insecticide free quality produce. The study finds support from Kumar and Kanta (2011) who reported significantly lower damage caused by the maize stem borer in the plots wherein *T. chilonis* was released @ 100 000 per ha on 12 and 15 day old maize crop and subsequently it increased the grain yield. Jalali and Singh (2003) studied the parasitization efficiency of four *Trichogramma* species, *viz*. *T. chilonis*, *T. japonicum*, *T. evanescens* and *T. dendrolimi*. Out of these, *T. chilonis* (maize strain) parasitized significantly more

Table 4 Effect of *T. chilonis* releases for the management of *C. partellus* on yield in *Kharif* maize during 2015

Treatment	Yield (q/ha)						Increase in yield over control (%)
	Roop Nagar	Hoshiarpur	SBS Nagar	Pathankot	Jalandhar	Mean	
T. chilonis @ 100 000/ ha	52.50[b]	45.90[a]	50.30[a]	46.67[a]	53.60[a]	49.79[b]	16.96
Deltamethrin 2.8 EC @ 200 ml/ha	56.40[a]	48.33[a]	53.60[a]	48.40[a]	56.80[a]	52.71[a]	23.82
Untreated control	45.40[c]	37.83[b]	43.40[b]	41.40[b]	44.80[b]	42.57[c]	
LSD (P=0.05)	2.54	7.45	6.47	4.57	5.42	2.21	

Means in a column followed by the same letters are not significantly different at P = 0.05.

Table 5 Effect of *T. chilonis* releases for the management of *C. partellus* on cost benefit analysis in *kharif* maize during 2014 and 2015

Treatment	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (₹)	Cost of treatment* (₹/ha)	Net return over control (₹/ha)	Cost: benefit ratio
2014						
T. chilonis @ 1,00,000/- per ha	50.48	6.06	7938.60	205.00	7734	1:37.72
Deltamethrin 2.8 EC @ 200 ml/ha	52.78	8.36	10951.60	360.00	10592	1:29.42
Untreated control	44.42					
2015						
T. chilonis @ 1,00,000/- per ha	49.79	7.22	9566.50	205.00	9362	1:45.67
Deltamethrin 2.8 EC @ 200 ml/ha	52.71	9.14	12110.50	360.00	11751	1:32.64
Untreated control	42.57					

Price of maize ₹ 1310 and ₹ 1325 per quintal during 2014 and 2015, respectively; *include trichocard/insecticide + labour cost; Price of Deltamethrin 2.8EC ₹ 550/litre; Price of tricho card ₹ 35 per card.

C. partellus eggs (77.9%) than the other species (38.1-55.7%) when released @ 100 000 per ha. Aggarwal and Jindal (2013) validated the biocontrol technology for the management of maize borer at farmers' field and reported significantly lower dead heart incidence in release treatment (3.85%) than untreated control (12.10%). The grain yield was significantly higher in biocontrol treatment (46.10 q/ ha) than in untreated control (37.13 q/ ha). Similarly Farid *et al*. (2007), while evaluating the impact of *Trichogramma* releases in reducing the damage caused by maize stem borer, reported 68.0% decrease in damage over control wherein, four weekly releases of *Trichogramma* pupae @ 8,000 per ha were made, starting from the first week of September. The present findings thus provide evidence for the ecofriendly management of maize stem borer through augmentative release of egg parasitoid. It could be an important component of IPM and a viable option for organic (insecticide free) maize production.

SUMMARY

To study the on-farm impact of egg parasitoid, *Trichogramma chilonis* (Ishii) against maize stem borer, *Chilo partellus* (Swinhoe), large scale demonstrations were conducted at farmers' field in main maize growing areas of Punjab during 2014 and 2015. Each field was divided into three blocks representing three treatments, viz. single release of *T. chilonis* @ 1,00,000 parasitoids per ha, farmers' practice (chemical control) and untreated control. The mean dead heart incidence in biocontrol treatment was 5.60% in 2014 and 4.35% in 2015 as compared to 4.02% and 3.13%, respectively in chemical control. However, both the treatments were significantly better than untreated control (12.98 and 9.91% dead hearts, respectively). The mean increase in yield over untreated control was 13.64 and 16.96% in parasitoid release fields as against 18.82 and 23.82% in chemical control fields during 2014 and 2015, respectively. Higher net returns were recorded in chemical control than in bioagent released fields. However, cost:benefit ratio was comparatively higher in parasitoid released fields (1:37.72-45.67) as against chemical control (1:29.42-32.64) during both the years.

ACKNOWLEDGEMENTS

The authors are thankful to the Head, Department of Entomology for providing necessary facilities to carry out present work. The authors are also thankful to Director, ICAR- National Bureau of Agricultural Insect Resources, Bengaluru, India for support and encouragement during the course of this study. Thanks are extended to the farmers for the interest and support shown by them in the smooth conduct of experiments at their maize fields.

REFERENCES

Aggarwal N and Jindal J. 2013. Validation of biocontrol technology for suppression of *Chilo partellus* (Swinhoe) on *kharif* maize in Punjab. *Journal of Biological Control* **27**: 278–84.

Bhimsen K C. 1977. Studies on some aspects of integrated control of maize borer, *Chilo partellus* (Swinhoe) (Crambidae: Lepidoptera). M Sc thesis, Punjab Agricultural University, Ludhiana, Punjab.

Bueno R, Bueno A D, Parra J R P, Vieira S S and de Oliveira L J. 2010. Biological characteristics and parasitism capacity of *Trichogramma pretiosum* Riley (Hymenoptera, Trichogrammatidae) on eggs of *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae). *Revista Brasileira de Entomologia* **54**: 322–7.

FAOSTAT. 2016. Food and Agriculture Organization of the United Nations. http://www.fao. org/faostat/en/#data/QC.

Farid A, Khan M I N, Khan A, Khattak S, Alamzeb U K and Sattar A. 2007. Study on maize stem borer, *Chilo partellus* (Swin.) in Peshawar valley. *Pakistan Journal of Zoology* **9**: 127–31.

Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*, 2nd ed, p 704. John Wiley and Sons Inc, New York, USA.

Jalali S K and Singh S P. 2003. Determination of release rates of natural enemies for evolving bio-intensive management of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). *Shashpa* **10**: 151–4.

Kumar V and Kanta U. 2011. Effectiveness of *Trichogramma chilonis* Ishii in the suppression of *Chilo partellus* (Swinhoe) in summer maize. *Journal of Biological Control* **25**: 92–7.

Kumar S, Kumar P, Bana J K, Shekhar M, Sushil S N, Sinha M, Sinha A K, Asre R, Kapoor K S, Sharma O P, Bhagat S, Sehgal M, Boopathi T, Amaresan N, Chattopadhaya C, Satyagopal K and Jeyakumar P. 2014. Integrated Pest Management Package for Maize. National Centre for Integrated Pest Management, New Delhi, p 44.

USDA-FAS. 2016. *World Agricultural Supply and Demand Estimates*. https://apps.fas. usda.gov/ psdonline/circulars/ production.pdf.

Pizzol J, Pintureau B, Khoualdia O and Desneux N. 2010. Temperature-dependent differences in biological traits between two strains of *Trichogramma cacoeciae* (Hymenoptera: Trichogrammatidae). *Journal of Pest Science* **83**: 447–52.

Prakash A, Rao J and Nandagopal V. 2008. Future of botanical pesticides in rice, wheat, pulses and vegetables pest management. *Journal of Biopesticides* **1**: 154–69.

Singh B. 2012. Role of pesticides in management of crop pests. (*In*) *Theory and Practice of Integrated Pest Management*, pp 76–83. Arora R, Singh B and Dhawan A K (eds.). Scientific Publishers (India), Jodhpur, pp. 76-83.