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Research Article

Effectiveness of *Trichogramma chilonis* Ishii in the suppression of *Chilo partellus* (Swinhoe) in summer maize

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ABSTRACT: Studies on the effectiveness of *Trichogramma chilonis* Ishii in the suppression of *Chilo partellus* in summer maize were carried out at Punjab Agricultural University, Ludhiana during summer 2006 and 2007. The mean total incidence of maize stem borer was minimum in maize plot with single release of *T. chilonis* @ 100,000/ha on 12-day-old crop (14.3%) followed by 15-day-old crop (15.3%) and incidence in these two was significantly lower as compared to untreated check (33.0%) and proved effective in reducing the incidence of maize stem borer and subsequently increased the maize yield. However, the pest incidence in all biocontrol treatments was higher than the maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (10.5%). The yield obtained from maize plot with single release of *T. chilonis* @ 100,000/ha on 12-day-old and 15-day-old crops (25.9 and 25.4 q ha^{-1}, respectively) was significantly higher than all other treatments except maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (26.2 q ha^{-1}). The parasitism rate of *C. partellus* eggs on maize plants was significantly higher in releases of *T. chilonis* @ 100,000 ha^{-1} on 12- and 15-day-old crop (44.8 and 43.1%, respectively) as compared to untreated check (4.4%) and plots treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (1.0%).

KEY WORDS: *Chilo partellus*, incidence, *Trichogramma chilonis*, recovery, yield, maize

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INTRODUCTION

Maize (*Zea mays* Linn.) is an important cereal crop which serves as a staple food for millions in the world. It is extensively used as food, feed, fodder and for production of starch, oil, liquor, dextrose, dyes, etc. (Khera and Dhillon, 1982). One of the major factors for the reduction of maize yield in the field is the pest complex of this crop. Sarup *et al.* (1987) listed 130 insect species attacking maize, of which the stem borer, *Chilo partellus* (Swinhoe) is a ubiquitous and key pest of maize and sorghum (Jotwani & Young, 1977). Maize stem borer has been reported to cause 26.7–80.4 per cent yield loss in different agroclimatic zones of India, depending upon pest population density and phenological stages of the crop at infestation (Chatterji *et al.*, 1969). Under Punjab conditions, it is reported to cause 57.70–79.40 per cent losses in grain yield (Singh and Sajjan, 1982).

Chemical control has failed to meet the desired level of success due to various reasons like low economic return and environmental pollution that affects non-target insects like predators and parasitoids (Sukhani & Jotwani, 1977; Lawani, 1982). So, there is a need to develop non-chemical methods for the control of maize stem borer. Hence, eco-friendly approaches like cultural practices, biocontrol, host plant resistance, etc. should be employed for the management of *C. partellus*. Large numbers of natural enemies of the stem borer have been identified for their potential use in biological control and these practices can be blended in an IPM programme. Keeping in view the above facts, the present study on the effectiveness of a biocontrol agent, *Trichogramma chilonis* in suppressing *C. partellus* in summer maize was undertaken.

MATERIAL AND METHODS

The studies were carried out at the Entomological Research Farm, Department of Entomology, Punjab Agricultural University, Ludhiana and farmers' fields in district Jalandhar during summer 2006 and 2007. Mass rearing of *C. partellus* was carried out in the Maize Entomology Laboratory, Department of Plant Breeding and Genetics, PAU, Ludhiana. Similarly, the culture of *Trichogramma chilonis* Ishii was maintained in the Biological Control Laboratory, Department of Entomology, PAU, Ludhiana. The mass rearing of *C. partellus* was done on artificial diet (Uma Kanta, 1985) followed by

Siddiqui *et al.* (1977). The composite maize was sown on 18.6.2006 in randomized block design comprising eight treatments with three replications and a plot size of 300 sq. m. each. A buffer zone of one meter was maintained for each treatment. The treatments were release of *T. chilonis* @ 50000, 75000 and 100,000 eggs ha^{-1} on 12-day-old crop, release of *T. chilonis* at 100,000 ha^{-1} on 15-day-old crop, two releases of *T. chilonis* @ 50000 per release ha^{-1} on 10-day and 13-day-old crop, two releases of *T. chilonis* @ 50000 per release ha^{-1} on 12-day and 15-day-old crop, recommended practice (Deltamethrin 2.8 EC @ 200 ml ha^{-1}) and untreated control. The eggs of *Corcyra cephalonica* parasitized by *T. chilonis* were glued to tricho cards. The required number of tricho cards depending upon the dose per hectare were cut into smaller pieces and attached to the underside of maize leaves at different stages of the maize crop and at different places in each plot. For recovery of *T. chilonis,* five egg clusters (having 35-40 eggs per cluster) of *C. partellus* were attached to the central whorl of the maize plants at different places in the field, one day after release of the parasitoids and were collected 24 hour later. During the second year of study, this experiment was repeated again on crop sown on 21.06.2007. Observations on leaf injury, dead hearts, total incidence and the number of larvae and pupae were recorded at 30 and 45 days after sowing and yield was recorded at harvest. The data was recorded from 100 plants selected at random from each plot. The grain weight at harvest was then adjusted to 15 per cent grain moisture content to obtain yield (Bhimsen, 1977). The data obtained on damage done by maize stem borer in percentage and per cent parasitism were subjected to analysis of variance.

RESULTS AND DISCUSSION

Among the release plots the leaf injury in plots with single release of *T. chilonis* @ 100,000 ha^{-1} on 12 and 15-day-old crop (8.3 and 9.0%, respectively) was significantly lower than all other treatments except deltamethrin 2.8 EC @ 200 ml ha^{-1} (8.7%) (Table 1). Greater leaf injury (18.3%) was observed in maize plot with single release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop and two releases of *T. chilonis* @ 50000 per release ha^{-1} on 10-day and 13-day-old crop and it was on a par with untreated check (19.7%). During 2007, among the biocontrol treatments, the per cent leaf injury due to maize stem borer was significantly lower in maize plots with single release of *T. chilonis* @ 100,000 ha^{-1} on 12- and 15-day-old crop (11.7 and 13.0%, respectively) as compared to untreated checks (22.7%). However, significantly lower leaf injury was recorded in the maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (9.0%) in comparison to all other treatments. From the pooled data (Table 1), it was observed that leaf injury caused by the maize stem borer in maize plot with single release of *T. chilonis* @ 1,00,000 ha^{-1} on 12-day-old crop (10.3%) and 15-day-old crop (10.7%) was statistically lower than all other treatments except deltamethrin 2.8 EC @ 200 ml ha^{-1} (8.8%). Among the other biocontrol treatments, two releases of *T. chilonis* @ 50000 ha^{-1} on 12 and 15-day-old crop was found to be effective as compared to untreated check. The maximum leaf injury was recorded in maize plot with two releases of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop (19.3%) followed by release of 50000 ha^{-1} on 10- and 13-day-old crop (18.9%) and leaf injury in these two was on a par with untreated plot (20.7%). Dead heart formation caused by maize stem borer during 2006 was minimum (2.3%) with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop and was on par with the maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (1.03%) but significantly lower than untreated check (10.3%) (Table 1). Among all the treatments, the maximum dead heart formation was recorded in maize plot with single release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop (8.3%) and was on a par with untreated check. Similarly during 2007, among the bio-control treatments, the dead heart formation due to maize stem borer was lowest with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop (5.7%) and it was on par with single release of *T. chilonis* @ 100,000 ha^{-1} on 15-day-old crop (6.03%) and two releases of *T. chilonis* @ 50000 ha^{-1} on 12 and 15-day-old crop (6.7%) but significantly lower than all other bio-control treatments and untreated check (13.7%). The dead heart formation was significantly lowest in maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (2.3%) in comparison to all other treatments. The pooled data (Table 1) of two years showed that the per cent dead heart formation caused by the maize stem borer was significantly less in maize plot with single release of *T. chilonis* at 100,000 ha^{-1} on 12-day-old crop (4.03%) and 15-day-old crop (4.7%) as compared to untreated check (12.03%), but was inferior to that in maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (1.7%). The dead heart formation in maize plot with single release of *T. chilonis* @ 50000 ha^{-1} on 12-day old crop (10.3%) was significantly higher than all other treatments except control (12.0%).

During 2006, the total incidence of maize stem borer in all the treatments ranged from 9.7 to 31.0 per cent (Table 2). The incidence was significantly lower in maize plot with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop and 15-day-old crop (10.7 and 11.3%, respectively) in comparison to untreated check

Table 1. Effect of *T. chilonis* on leaf injury and dead hearts caused by *C. partellus* in summer maize

Treatment	Leaf injury*(%)		Dead hearts*(%)	
	2006	2007	2006	2007
T. chilonis @ 50000 ha^{-1} on 12-day-old crop	18.33 (25.33)**	20.33 (26.76)	8.33 (16.73)**	12.33 (20.53)
T. chilonis @ 75000 ha^{-1} on 12-day-old crop	16.67 (24.06)	18.67 (25.57)	6.07 (13.80)	10.67 (19.02)
T. chilonis @ 100000 ha^{-1} on 12-day-old crop	9.00 (17.38)	11.67 (19.94)	2.33 (7.33)	5.67 (13.72)
T. chilonis @ 100,000 ha^{-1} on 15-day-old crop	8.33 (16.73)	13.00 (21.06)	2.67 (9.26)	6.03 (14.14)
Two releases of *T. chilonis* @ 50000 ha^{-1} each on 10- & 13-day old crop	18.33 (25.28)	19.07 (25.79)	5.67 (13.41)	8.67 (17.04)
Two releases of *T. chilonis* @ 50000 ha^{-1} each on 12- & 15-day old crop	14.67 (22.49)	14.67 (22.46)	3.33 (10.33)	6.67) (14.85)
Deltamethrin 2.8 EC @ 200 ml ha^{-1}	8.67 (17.04)	9.00 (17.38)	1.03 (4.62)	2.33 (8.74)
Untreated plot (Check)	19.67 (26.30)	22.67 (28.46)	10.33 (18.66)	13.67 (21.67)
CD (P = 0.05)	(1.69)	(2.32)	(3.07)	(2.72)

*Mean of three replications; **arc-sine values

Table 2. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in summer maize

Treatment	Total incidence*(%)		Number of larvae and pupae*		Yield* (q ha^{-1})	
	2006	2007	2006	2007	2006	2007
T. chilonis @ 50000 ha^{-1} on 12-day-old crop	26.67 (31.06)**	32.67 (34.83)	2.77	2.67	19.92	18.87
T. chilonis @ 75000 ha^{-1} on 12-day-old crop	21.67 (27.68)	29.33 (32.78)	2.33	2.33	21.08	20.13
T. chilonis @ 100,000 ha^{-1} on 12-day-old crop	10.67 (18.97)	17.33 (24.57)	1.97	1.93	26.92	24.93
T. chilonis @ 100,000 ha^{-1} on 15-day-old crop	11.33 (19.64)	19.03 (25.82)	1.97	2.06	26.65	24.32
Two releases of *T. chilonis* @ 50000 ha^{-1} each on 10- & 13-day old crop	23.00 (28.57)	27.67 (31.69)	2.13	2.47	22.38	221.17
Two releases of *T. chilonis* @ 50,000 ha^{-1} each on 12- & 15-day old crop	17.33 (24.56)	21.33 (27.49)	2.00	2.13	24.09	22.95
Deltamethrin 2.8 EC @ 200 ml ha^{-1}	9.67 (17.97)	11.33 (19.59)	1.73	1.90	27.17	25.32
Untreated plot (Check)	31.00 (33.81)	36.33 (37.05)	2.83	3.10	19.53	18.62
CD (P = 0.05)	(2.15)	(2.48)	0.43	0.45	1.62	1.72

*Mean of three replications; **arc-sine values

(31.0%) and were on par with that in maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (9.7%). Among the treated plots, the maximum incidence was found in maize plot with single release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop (26.7%). Similarly in 2007, the total incidence of stem borer was significantly lower with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop (17.3%) and 15-day-old crop (19.03%) as compared to untreated check (36.3%), but these were inferior to the plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (11.3%). Among the treatments, the maximum incidence was found in maize plot with single release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop (32.7%). Higher yield was obtained with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop (26.9 q ha^{-1}) followed by 15-day-old crop (26.6 q ha^{-1}) and yield in these two was significantly higher than all other treatments except deltamethrin 2.8 EC @ 200 ml ha^{-1} (27.2 q/ha) (Table 2). Similarly during 2007, the yield was significantly higher with single release of *T. chilonis* at 100,000 ha^{-1} on 12-day-old and 15-day-old crops (24.9 and 24.3 q ha^{-1}, respectively) in comparison to untreated check (18.6 q ha^{-1}) and was comparable to deltamethrin 2.8 EC @ 200 ml ha^{-1}. The pooled data (Table 2) showed that yield obtained with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop and 15-day-old crop (25.9 and 25.5 q ha^{-1}, respectively) was significantly higher than all other treatments except deltamethrin 2.8 EC @ 200 ml ha^{-1} (26.2 q ha^{-1}).

The larval and pupal population in all the biocontrol treatments except single release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop was significantly lower than untreated check (2.83) during 2006 (Table 2). The number of larvae and pupae per plant recovered from maize plot with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop, 15-day-old crop, and two releases of *T. chilonis* at 50,000 ha^{-1} on 12- and 15-day-old crop and @ 50000 ha^{-1} on 10- and 13-day-old crop (1.97, 1.97, 2.0, and 2.13, respectively) was comparable deltamethrin treatment (1.73). The maximum number of larvae and pupae were recovered in maize plot with release of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop (2.77) and it was significantly higher than all other treatments except the plots with single release of *T. chilonis* @ 75000 ha^{-1} on 12-day-old crop (2.33) and untreated control (2.83). During 2007, significantly less number of larvae and pupae per plant were recovered from maize plot with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day-old crop, 15-day-old crop, two releases @ 50000 ha^{-1} on 12 and 15-day-old crop and @ 75000 ha^{-1} on 12-day-old crop (1.93, 2.06, 2.13 and 2.33, respectively) in comparison to untreated check (3.10) and statistically they were on par with maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (1.90). The studies made over two years clearly indicated that significantly lower number of larvae and pupae were recovered from maize plots with single release of *T. chilonis* @ 100,000 ha^{-1} on 12-day old crop, 15-day-old crop and two releases of

Table 3. Parasitism of *C. partellus* eggs by *T. chilonis* in summer maize

Treatment	Per cent parasitisation*	
	2006	2007
T. chilonis @ 50,000 ha^{-1} on 12-day old crop	19.73 (26.35) **	21.82 (27.81)
T. chilonis @ 75,000 ha^{-1} on 12-day old crop	28.11 (31.98)	32.84 (34.51)
T. chilonis @ 1,00,000 ha^{-1} on 12-day old crop	44.84 (42.01)	55.75 (48.30)
T. chilonis @ 1,00,000 ha^{-1} on 15-day old crop	43.10 (41.02)	52.85 (46.62)
Two releases of *T. chilonis* @ 50,000 ha^{-1} each on 10- & 13-day old crop	34.51 (35.93)	40.40 (39.44)
Two releases of *T. chilonis* @ 50,000 ha^{-1} each on 12- & 15-day old crop	35.99 (36.84)	41.96 (40.35)
Deltamethrin 2.8 EC @ 200 ml ha^{-1}	1.00 (5.72)	1.62 (7.06)
Untreated plot (Check)	4.47 (12.09)	7.03 (15.16)
CD ($P = 0.05$)	(3.68)	(4.99)

*Mean of three replications; **arc-sine values

T. chilonis @ 50000 ha^{-1} on 12- and 15-day-old crop (1.96, 2.01 and 2.05 respectively), in comparison to untreated check (2.97) and was comparable with the maize plot treated with deltamethrin 2.8 EC @ 200 ml ha^{-1} (1.82).

The parasitism in all the released plots was significantly higher as compared to untreated check (4.47%) and chemical control (1.00%) during 2006 (Table 3). However the parasitisation rate of *C. partellus* eggs was releases of *T. chilonis* @ 100,000 ha^{-1} on 12- and 15-days old crop (44.84 and 43.10%, respectively) was significantly higher than all other treatments. The parasitism was lower at lower dosages of *T. chilonis* @ 50000 ha^{-1} (28.11%) and 75000 ha^{-1} (28.11%) than at higher dosages @ 100,000 ha^{-1}. The minimum parasitisation (1.00%) was observed in chemical control. During 2007, the parasitisation rate of *C. partellus* eggs was significantly higher in releases of parasitoid @ 100,000 ha^{-1} on 12 and 15-days-old crop (55.75 and 52.85%, respectively) in comparison to untreated check (7.03%). The per cent parasitisation was lower at lower dosages of 50000 ha^{-1} (21.82%) than at higher dosages of 100,000 ha^{-1} and was minimum (1.62%) in chemical control as compared to all other treatments. From the pooled data (Table 3), it was seen that the parasitisation rate of *C. partellus* eggs was significantly higher in releases of *T. chilonis* @ 100,000 ha^{-1} on 12 and 15-days-old crop (50.29 and 47.97%, respectively) as compared to all other treatments. It was lower at lower dosages of *T. chilonis* @ 50000 ha^{-1} and 75000 ha^{-1}, (20.78 and 30.97%, respectively) than at higher dosages of *T. chilonis* @ 100,000 ha^{-1}. Significantly lower parasitism (1.14%) was recorded in maize plants sprayed with deltamethrin.

From the above findings it was inferred that damage caused by the maize stem borer was significantly minimum in maize plot where *T. chilonis* was released @ 100,000 ha^{-1} on 12-day-old crop and 15- day-old crop and proved effective in reducing the incidence of maize stem borer and subsequently increased the yield. The maximum damage was found in maize plot with releases of *T. chilonis* @ 50000 ha^{-1} on 12-day-old crop. Releases of *T. chilonis* @ 100,000 ha^{-1} on 12- and 15-day-old crop also led to reduction in the number of larvae and pupae recovered per plant. The parasitism rate of *C. partellus* eggs was significantly higher in releases of *T. chilonis* @ 100,000 ha^{-1} on 12- and 15-days-old crop (50.29 and 47.97%, respectively). Significantly low parasitism (1.14%) of maize stem borer was found in maize plants sprayed with deltamethrin 2.8 EC at 200 ml ha^{-1}.

The present findings are in accordance with the results obtained by Jalali and Singh (2003a). According to them, among the four species, *T. chilonis* (maize strain) parasitized significantly more *C. partellus* eggs (77.9%) than the other species (38.1-55.7%) when released @ 100,000 ha^{-1}. It was again observed by Jalali and Singh (2003b) that in fodder maize, *T. chilonis* was most promising as an egg parasitoid and *Cotesia flavipes* (Cameron) as larval parasitoid for field studies in India. Egg parasitisation by *T. chilonis* ranged from 41.9 to 42.8 per cent after the first release and it rose to 75.2 to 76.8 per cent after the third release in plots where parasitoids were released at a 3-day interval. In plots where parasitoids were released in a 5-day interval, parasitisation rates increased from 24.8 to 27.4 per cent to 62.3 to 62.6 per cent. Crop yield was higher in releases of *T. chilonis* at 3-day intervals compared to 5-day intervals. *T. chilonis* was more efficient in controlling the pest compared to *C. flavipes*. The release of *T. chilonis* at 3-day interval was the best treatment to obtain higher yield in summer fodder maize as compared to 5-day interval releases at 1,00,000 ha^{-1}. Similarly, Rawat *et al.* (1994) also found that inundative releases of *T. chilonis* were effective against *C. partellus* in maize crop in Himachal Pradesh. In contrast to present findings, Sohail *et al.* (2003) found six maize cultivars (Agaiti-85, Akbar, Golden, EV-1098, Pak-afgoyee and EV-5089) for resistance to *C. partellus* in Pakistan and found that *T. chilonis* in impregnated cards placed in plots was not effective in controlling infestation in maize plots.

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